GUIDELINES FOR COAL EXPLORATION

Province of British Columbia

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Energy, Mines and
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NOTE

These Guidelines refer to the *Mines Act*. At time of printing the *Mines Act* was as yet unproclaimed and therefore not in force. Legislative authority at time of printing was the *Coal Mines Regulation Act* (1979).

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I.

LEGISLATION PERTAINING TO ENVIRONMENTAL PROTECTION AND RECLAMATION

I. LEGISLATION PERTAINING TO ENVIRONMENTAL PROTECTION AND RECLAMATION

Authority for regulation of coal mining activity is vested in the *Mines Act* and is administered by the Ministry of Energy, Mines and Petroleum Resources. Section 6 of the Act requires that before beginning to develop a mine a person 'shall file with the Chief Inspector a report and plan of the system suitable to the Chief Inspector under which it is proposed to work the mine,' and written approval of the Chief Inspector must be received prior to commencement of work.

Section 7 requires that any person carrying out exploration, mining, or preparatory work for production from a mine must 'carry out a program for the protection and reclamation of the surface of the land and watercourses' and 'leave the land and watercourses in a condition satisfactory to the Minister.'

Under section 7, approval of this program must be obtained prior to the commencement of exploration.

After approval of the program, reclamation bonding is established and a permit is issued by the Minister. Permits are issued on a permanent basis, but exploration programs must be approved annually.

The following sections outline the procedures an operator must follow to carry out a coal exploration program:

1.1 TO OBTAIN A RECLAMATION PERMIT (First Work on a Major New Area)

The applicant should as soon as possible before commencement of work, preferably several months, submit Form 6–7, *Notice of Work on a Coal Licence* and *Reclamation Program,* as noted on the forms (Appendix A-1).

- Chief Inspector – one copy
- Senior Reclamation Inspector – seven copies
- Inspector of Mines and Resident Engineer for the District – one copy
- Reclamation Inspector – Technician – one copy
- Regional offices of Fish and Wildlife, Forestry, Water Resources, Lands, and Agriculture – one copy each

A 1:50 000 map showing proposed work and reclamation is to be attached to each of the copies; also a working scale map (usually 1:10 000) or air photograph showing work and reclamation is to be attached to three copies – one to the Senior Reclamation Inspector, one to the Inspector of Mines and Resident Engineer for the District and one to the Reclamation Inspector – Technician.

Ministry of Energy, Mines and Petroleum Resources (MEMPR): Upon receipt of the above report, the Senior Reclamation Inspector advises the applicant of the procedure for publishing a *Notice of Filing* in the *British Columbia Gazette* and in local newspapers.

Applicant then publishes *Notice of Filing* and advises Senior Reclamation Inspector of date of publication.

MEMPR: Within 60 days of the filing of the report, the Advisory Committee on Reclamation, chaired by the Chief Inspector, reviews the application and, if accepted, will submit it to the Minister for approval.

The Senior Reclamation Inspector then advises the applicant of permit approval and establishes the required bonding (security deposit). *Receipt and Agreement* forms are forwarded to him with instructions for filing of the bond. The Chief Inspector then advises the applicant of approval of work.

APPLICANT: Arranges security deposit with bank and has completed *Receipt and Agreement* forms sent to Senior Reclamation Inspector.

MEMPR: Upon receipt of the above form, the *Reclamation Permit* authorizing commencement of surface work is issued to the applicant.

NOTE: If the proposed work does not involve mechanical disturbance of the surface of the land, a protective program and a permit are not required.

1.2 TO OBTAIN ANNUAL PROGRAM APPROVAL

OPERATOR: As soon as possible before commencement of work, operator submits Form 6–7, *Notice of Work on a Coal Licence* and *Reclamation Program* as noted previously, with the exception that only one copy goes to the Senior Reclamation Inspector. (Regional staff forms a Regional Advisory Committee on Reclamation under the chairmanship of the Reclamation Inspector – Technician, who recommends program approval to the Chief Inspector.) The operator is subsequently advised of approvals under sections 6 and 7, which authorize commencement of the work.

MEMPR: Reclamation Inspector – Technician makes field inspections as required, during exploration program. (Bonding may be revised at any time on the basis of total exploration disturbance, environmental sensitivity, and the company's performance record.)

OPERATOR: At least one week prior to completion of work and reclamation, operator notifies Reclamation Inspector – Technician of cessation of work (Form 6–7 is again completed for use by the Inspector of Mines and Resident Engineer for the District and the Reclamation Inspector – Technician in the final inspection.

MEMPR: Makes final inspection of property.

OPERATOR: Within 30 days of completion of annual exploration program, operator submits finalized *Notice of Work on a Coal Licence* and *Reclamation Program* to the following:

- Chief Inspector of Mines
- Senior Reclamation Inspector
- Reclamation Inspector – Technician (who advises operator of status of reclamation)

By March 1st of the following year, operator submits Annual Reclamation Report to the following:

- Senior Reclamation Inspector
- Inspector of Mines and Resident Engineer for the District.
- Reclamation Inspector-Technician

This is a detailed report on the reclamation program completed during the year. It is not required on minimum disturbance programs such as geological surveys or helicopter-supported programs.

1.3 TO TERMINATE THE RECLAMATION PERMIT

OPERATOR: Operator applies to the Senior Reclamation Inspector for release of bond.

MEMPR: Senior Reclamation Inspector arranges for release of bond on the basis of satisfactory field inspections and reclamation reports.

II.

PLANNING THE FIELD WORK

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2.1 GENERAL PRINCIPLES

Planning is a necessary part of an exploration program. Through planning, problems and conflicts can be identified well in advance so that they may be avoided or accommodated with the least amount of difficulty. By anticipating the needs for equipment and materials, supplies may be acquired in advance so that work schedules can proceed without delay.

The nature of an exploration program will be determined by the present knowledge of coal resources in the exploration area, by the type of geological information that is required, and by the budget available. On reconnaissance projects, where data is to be collected from a broad area, helicopter-supported geological mapping and drilling have several environmental advantages. Experience has shown that a helicopter-supported program can be economical if it eliminates 2 kilometres of road construction or more, and planning for environmental protection is greatly reduced since the impact of these methods is minimal. If, however, more detailed information based on road access exploration is necessary, more extensive layout planning will be required.

Before a network of roads, drill sites, trenches, and adits may be designed, areas that may be sensitive to exploration activity should be defined (Fig. 2.1). These 'sensitivity zones' are delineated in areas with a high potential for construction or reclamation problems or where conflicts with other resources will arise. These areas should be outlined on the exploration base map so that disturbance within their boundaries can be minimized or avoided and potential problems can be anticipated. The major areas of sensitivity in the northeast and southeast coal areas have been identified and described in the following sections.

In addition to the terrestrial zones noted above, sensitivities exist with respect to fish and water quality (Fig. 2.2). These are most often affected where roads cross watercourses, or parallel them, in steep terrain. The installation of as few crossings as possible and avoidance of V-shaped valleys are a good planning rule.

There is a large amount of information available which can aid in the planning of an exploration program. Up-to-date aerial photographs and topographic maps can provide a great deal of useful information, as can maps of geology, soils, vegetation, and wildlife capability. Appendix B describes a number of types of maps and air photographs, how they may be used, and where they can be obtained. This list is not complete, however, since many agencies prepare their own unpublished maps which change frequently.

With respect to the planning of roads, there are a number of ways that the mileage of road and the total disturbance may be minimized:

- Make the maximum use of geological mapping as an exploration tool.
- Evaluate each drill hole, trench, and adit as to whether the information it supplies is worth the environmental as well as economic cost.

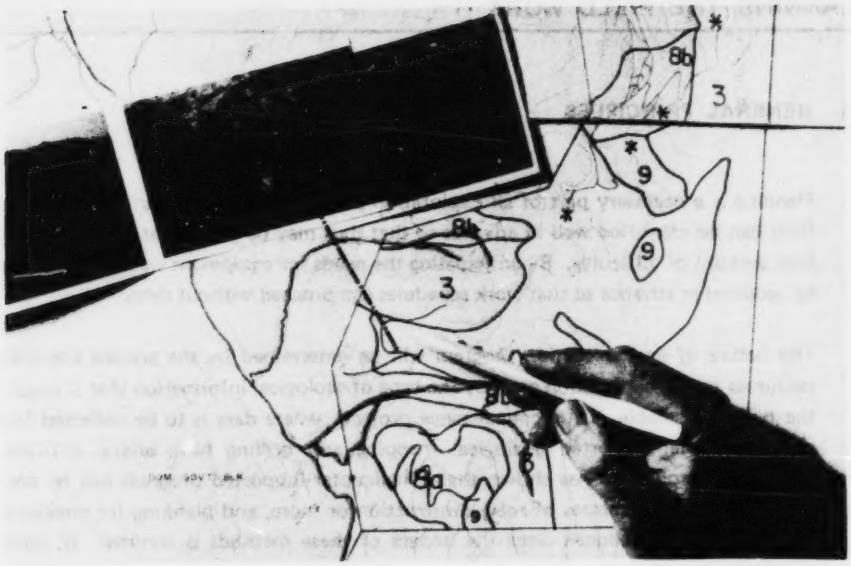

Figure 2.1. Advance planning of exploration activities enables sensitive areas to be avoided and, where this is not possible, minimizes the disturbance which does occur. Cost effectiveness of reclamation work is improved and possibly also the cost effectiveness of exploration.

Figure 2.2. A section of stream which is highly productive of fish and aquatic life. Those portions of permanent watercourses, which are of clear quality when not in freshet and which produce bars of pea to baseball size gravel, provide spawning habitat for trout and other fish. These areas are often unique, are generally about 1 per cent gradient, and may be used by fish which migrate from streams and lakes many kilometres distant.

- Use existing roads wherever possible and avoid duplication of access routes. Road duplication is an indication of a serious lack of planning and may influence amount of bonding established.

- Use a few permanent main roads with spurs leading to drill or trench sites to create the most efficient pattern and allow for reclamation of spurs when work in that area is complete.

- Use tracked vehicles in alpine tundra in lieu of road construction (Fig. 2.3). When properly located, this type of access can greatly reduce disturbance. Routes should be carefully staked and flagged so that tracked vehicles are confined to a common corridor.

Figure 2.3. Access across tundra area by tracked vehicle. These routes should be clearly marked by stakes and flags and their use should be restricted to tracked vehicles.

2.2 RECLAMATION PLANNING

Reclamation should be planned as part of the exploration program so that it will be completed by the end of each season. In the case of winter programs, site preparation and seeding of disturbed areas should be planned for the following spring. A final inspection of exploration sites by the Reclamation Inspector – Technician is required one week prior to the end of each program.

Reclamation work is usually carried out by exploration personnel but if conducted by local contractors, it is best to contact these firms early in the season to ensure that they will be available. In either case, personnel should be thoroughly briefed so that they are familiar with reclamation procedures.

Reclamation equipment, culverting, seed, and fertilizer should be acquired at the beginning of the program to ensure that they will be available when required. In many cases, the appropriate equipment, seed mixes, and fertilizer types (*see* Chapter IV – Reclamation) are not available

locally and must be ordered well in advance to allow for delivery time. Occasionally certain species will not be available, requiring review with the Reclamation Inspector – Technician.

Soil erosion ratings depend upon the texture of the soil parent material and slope of the land. The following table (modified from Vold, 1977) outlines variation in erosion hazard depending upon slope and texture of surficial material. The effect of two further factors should, however, be borne in mind: the beneficial effect of a small amount of fines in the soil mass which acts as a binder; and consolidation, for example, glacial till which greatly improves a given soil's stability.

In summary, the erosion hazard is high in fine texture soils on steeply sloping land. The combination of both fine-textured soil and steeply sloping land is where the major erosion problems are likely to occur.

2.2.1 SENSITIVITIES IN THE PEACE RIVER COAL BLOCK

Alpine Zone

Alpine tundra offers excellent habitat for caribou, bighorn sheep, mountain goat, grizzly bear, and ptarmigan. Growth conditions for vegetation in the alpine are very severe, making natural and seeded revegetation slow and causing surface disturbance to remain visible for a long period of time.

Because tundra is highly sensitive and occurs only in small discontinuous areas, exploration work above treeline should be kept to a bare minimum.

In planning work in alpine regions the tundra may be broadly divided, according to moisture conditions into dry, mesic, and wet tundra. The term 'mesic' refers to areas of moderate moisture conditions.

Dry Tundra

This unit is generally associated with scree slopes and barren ridges and is distinguished by rocky soils with a low cover of stunted vegetation. Low moisture availability and extreme exposure to wind, sun, and frost make dry tundra sites very unproductive of

vegetation. Bare, rocky slopes and ridges are excellent construction sites and should be used whenever possible. Although vegetation is sparse, it is nevertheless important as winter range for wildlife because it may blow clear of snow during winter. Work in dry tundra areas should therefore be carried out with minimum disturbance of existing vegetation.

Mesic Tundra

Mesic tundra covers most of the alpine zone. Revegetation in this unit is difficult but can be successfully accomplished if appropriate procedures are used (*see* Chapter IV – Revegetation). Steep slopes should be avoided because of erosion potential. In general however, mesic tundra is the best alpine area in which to locate exploration activities.

Wet Tundra

Wet tundra is usually found on lower slopes but may occur as small pockets wherever moisture collects. It can be distinguished by the luxuriant growth and thick layer of moss over humus soils. These sites revegetate rapidly if appropriate procedures are used but should be avoided because of the inherent seepage which causes problems in drainage and erosion control. Relocating the road as little as 10 metres uphill may avoid many construction and maintenance problems.

Krummholz Zone

The fringe of stunted forest that occurs along the treeline is known as the Krummholz Zone. This mosaic pattern of meadow and forest is highly utilized by caribou, bighorn sheep, and mountain goat both in winter and summer. Construction in this zone should be reduced to a minimum.

Valley Bottoms

Valley bottoms experience milder winters and less snowfall than surrounding areas and thus provide high quality habitat for ungulates during critical winter periods. In these areas, disturbance of the animals may decrease winter survival so that the impact of construction is greater than would be expected from direct loss of habitat.

2.2.2 SENSITIVITIES IN THE CROWSNEST COALFIELD

Coal exploration in the southeast part of the province takes place, for the most part, below treeline. Sensitivity for reclamation is, therefore, reduced since the more moderate subalpine conditions allow successful revegetation without extreme measures. However, wildlife values are high in many areas and planning should be done to avoid serious conflict. Sensitive areas in descending order of importance are as follows:

Grasslands

Grasslands are found on steep south-facing slopes and provide good summer and excellent winter range for ungulates (Fig. 2.4). Soils may be erodible, making over-

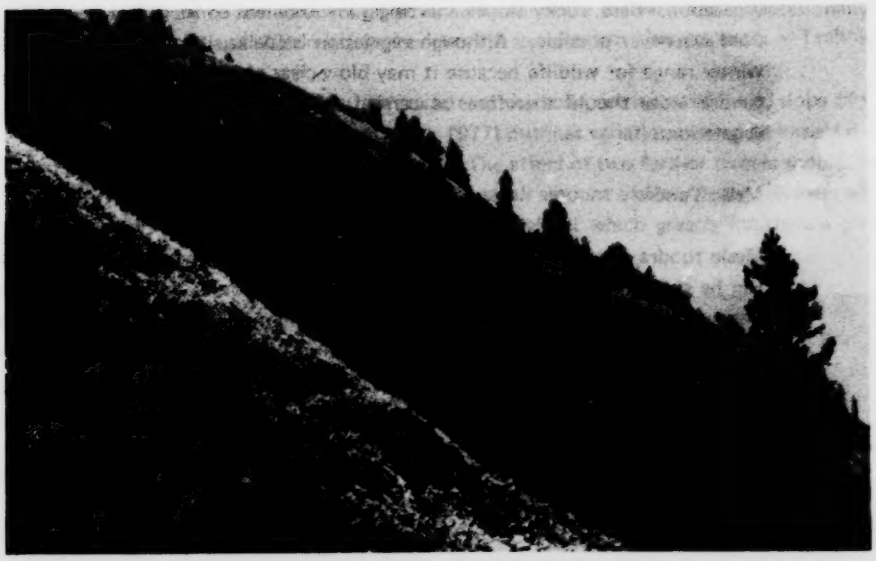

Figure 2.4. Steep south-facing grassland in southeastern British Columbia. These areas may constitute winter range, and should if possible be avoided.

steepened cut and sidecast slopes unstable. Grassland slopes may constitute valuable wildlife areas and exploration should entail minimum disturbance. Should disturbance be necessary then restoration will be required as completely and rapidly as possible.

Valley Bottoms

The flat alluvial terraces adjacent to major creeks and rivers provide good summer and winter range for elk, deer, and moose. Impact will result from both elimination of habitat and provision of access.

Fire Succession Slopes

These slopes, with a dense cover of willow, alder, and pine, can provide good winter range for ungulates, depending on snow conditions. Erosion hazard can occur in fine-textured soils.

III.

CONSTRUCTION

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3.1 CLEARING AND SLASH ABATEMENT

Clearing of forests and slash disposal are controlled under the jurisdiction of the Ministry of Forests. Where timber is to be cut or destroyed in exploration operations, a *Licence to Cut Timber* must be obtained from the local Ministry of Forests' office. Similarly, for timber to be used in mine development, a *Free-Use Permit* must be obtained. Pursuant to section 117 of the *Forest Act,* an order to abate slash hazard will be issued when required and will generally call for slash treatments similar to the following:

CLEARING

- Due to the loss of merchantable timber involved, prelogging of road rights-of-way is encouraged and, in some areas, may be required. In this procedure, merchantable timber, usually in lengths greater than 2.5 metres long with a top diameter over 15 centimetres, is decked and later sold by the Ministry of Forests. Prelogging can yield a more stable road bed and offset slash abatement costs.

- On main roads, all trees may be required to be felled onto the right-of-way, and those trees not utilized totally disposed of by burning or burying.

- On temporary roads and on drilling, trenching, aditing, or similar sites, all trees pushed over may be disposed of by lopping and scattering. In no case shall trees be left leaning into marginal timber. Total disposal is required within 400 metres of where any temporary road crosses a river or permanent main road.

HAZARD ABATEMENT

Disposal by Burning

All burning is required to be done under a permit issued by the local Forest Service. Within the Prince George and Prince Rupert Forest Regions a permit is only required between April 15 and October 15. Periods of high fire hazard may result in the cancellation of burning permits until more favourable conditions prevail.

Material under 20 centimetres in diameter may be required to be piled not less than 5 metres away from the marginal forest and burned when weather conditions permit. Larger material may be burned in a similar manner, or, if this is not possible, bucked so that it is in close contact with the ground and windrowed at least 5 metres from the marginal forest. Unburned stumps may be scattered singly along the right-of-way along with any charred material remaining after burning. Debris may not be left bunched or in piles.

Disposal by Burying

Burying is an acceptable method of slash disposal in most situations but requires a high level of supervision to ensure a satisfactory job.

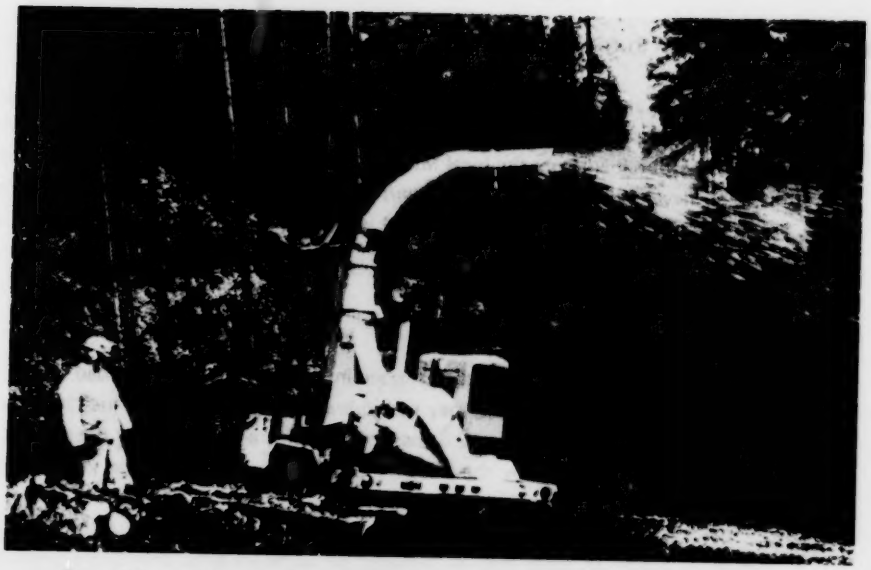


Figure 3.1. Chipper being used for slash abatement in southeastern British Columbia.

Figure 3.2. Chips scattered as a surface dressing.

Disposal areas must be cleared and a pit constructed to receive slash. Material to be buried must be cut into lengths less than 4 metres long and compacted within the pit so that nothing protrudes above ground level. Compacted piles should then be covered with at least 1 metre of mineral soil then seeded and fertilized.

Disposal by Lopping and Scattering

On winter or temporary access roads, provided their width is less than 10 metres, slash may be disposed of by lopping and scattering. When this method is used, all trees felled must be limbed and the branches scattered. Boles of trees must be cut from the stump at the root crown and bucked so that they lie in close contact with the ground.

Chipping

Chippers have been used successfully for the disposal of slash less than 25 centimetres in diameter (Fig. 3.1). When used in conjunction with prelogging, the requirement for burning or burying is greatly reduced.

Chips are utilized by spreading to a depth not exceeding 5 centimetres (2 inches) over recently seeded sites with subsequent fertilization with 220 kilograms per hectare (200 pounds per acre) of 21-0-0. This fertilization is necessary because decomposing wood chips have a high requirement for nitrogen and will reduce soil nutrient levels if not fertilized. Chip mulches may be very useful to cover dark-coloured trench or adit waste to reduce the high surface temperatures (Fig. 3.2). The light-coloured chips absorb less heat and surface temperatures are decreased to a level more favourable to plant growth.

3.2 ROAD CONSTRUCTION

The following sections outline a number of suggestions for road design and construction procedures.

3.2.1 GENERAL

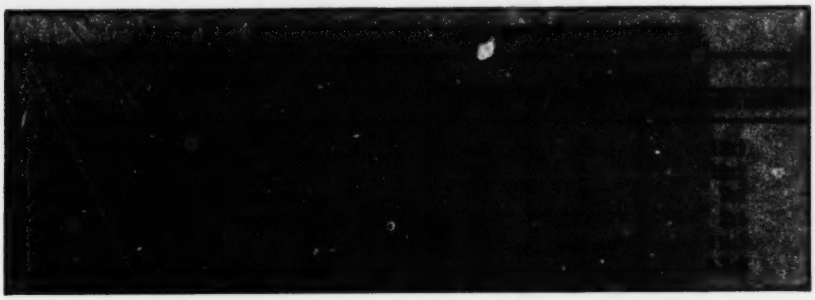
- Where possible, avoid sensitive areas (Chapter II). If these areas cannot be avoided, they should be evaluated in the field before construction begins so that specific drainage and erosion control measures can be taken.

- Locate roads to fit the topography making use of natural benches, ridgetops, and flatter slopes to avoid extensive cuts and fills. This will not only reduce construction costs but will avoid the possibility of unstable cut or fill slopes.

- Avoid steep slopes adjacent watercourses.

- Design roads to keep grades as low as possible. This may increase the length of road to be built but will reduce the likelihood of road surface erosion, lead to lower maintenance costs, and reduce possibility of stream sedimentation. During wet weather steep road grades (greater than 15 per cent) often make access difficult or impossible with two-wheel drive vehicles (Table 3.1). Short sections

steeper than the predetermined maximum may, however, be necessary to avoid areas of seepage or unstable soils.



- Proposed access routes should be inspected on foot and flagged in advance of construction equipment. Site specific relocations may then be made at difficult sites.

- Only a minimum area should be cleared for borrow pits, having due regard for ditching and slash disposal. In areas of high watertable, positive drainage of the borrow pit may be required.

- Road gravel should be obtained from dry quarries and not from stream channels. Alterations of stream channels contravene the Federal *Fisheries Act.*

- Where construction must take place in unstable soils or adjacent to major streams, advantage should be taken of periods of dry weather. In the northeast particularly, roads constructed in wet weather may suffer continuous erosion.

- In level terrain such as alpine tundra, where cuts and fills are not required, tracked vehicles should be used for access without roadway construction. Winter access routes, however, should be located in areas with sufficient snow cover to prevent disturbance of underlying soils and vegetation. Road alignments may be required to be flagged to ensure that travel is confined to selected routes. This is especially important during winter 'white-outs.'

- Where roads are constructed through wooded areas which have been identified as critical wildlife habitat, road design should provide for escape of wildlife from the roadway. This reduces the possibility of vehicle/wildlife collisions and allows escape from road hunters. Continuous slash piles should be breached if they exceed 400 metres.

- Ditches and crossdrains should be installed as part of the construction program. This will remove water from the road surface as it is being completed and will ensure drier, more stable working conditions. The grading and drainage of a new road should be completed before the end of the season so that the road surface will not be eroded by fall rains or spring breakup.

- Fill sections of exploration roads should not include snow or ice.

- The top of cut sections of exploration roads can be stabilized by reducing the slope angle, rounding the tops of the slopes, and falling trees that are undercut by erosion. The toes of cut slopes if left undisturbed during maintenance should stabilize. This may be assisted by leaving a top dressing of light slash, or by immediate seeding and/or mulching. In very difficult situations, slopes may be rip-rapped, terraced, or cribbed to prevent failure.

- Berms are a safety feature on roads and should not be considered as part of the drainage system. They should be left on roads traversing steep slopes and may be used to protect deep fills, but if left undrained at appropriate intervals, they may cause failure and/or erode the road surface.

- If road locations across steep slopes cannot be avoided, plan to reduce the road width or to endhaul material. Reducing road width may require special equipment such as small caterpillars with 'U' blades. Endhauling will also require special equipment such as a backhoe and dump truck. A stable site for the disposal of waste should be located and cleared before hauling begins.

- It has been demonstrated in the northeast that road construction can be successfully carried out during winter months under certain conditions. The main deterrents to winter construction are excessive snow depths, extreme ground-frost conditions, and steep topography. Given favourable conditions, however, construction programs undertaken during winter months may prove less damaging than construction during the summer, particularly in areas where high ground-water levels can result in serious erosion and stability problems during summer months. Properly constructed ditches and culvert crossings will control ground-water and surface runoff during spring breakup, resulting in a more stable road bed.

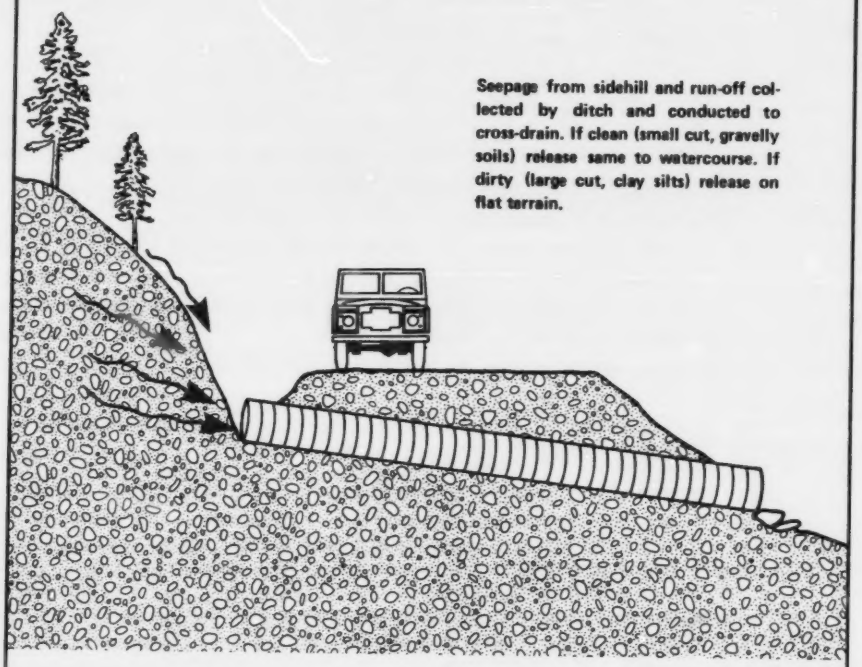
In forested areas, sufficient right-of-way should be cleared to facilitate removal of snow from the proposed road grade. Winter construction requirements will be set on a site specific basis.

3.2.2 DRAINAGE

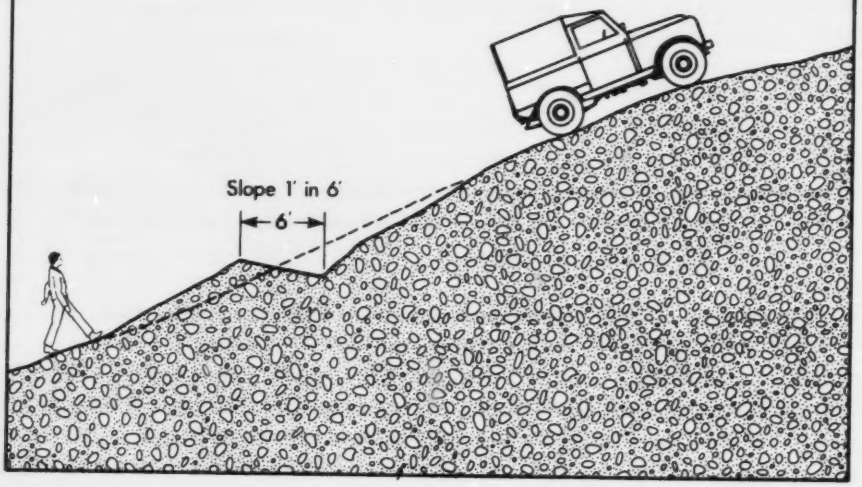
A good drainage system should be constructed as part of the road building program to control runoff from the road surface, collect and control seepage, and reduce the saturation of poorly drained soils.

Drainage design is an important element of road layout. Time spent, before construction, in identifying the drainage requirement of each section of road and ensuring that the appropriate machinery and materials are available will be compensated by savings in construction and maintenance costs. Drainage systems should be designed with regard to the type of soil in the vicinity of the new road and the maximum expected runoff. Personnel that have had local road building experience will often be the best source of information for drainage requirements.

CULVERTED CROSS-DRAIN



WATER BAR ACROSS SELDOM USED OR UNUSED ROAD GRADE



The natural drainage capacity and erodibility of a site depends upon the soil type. Roads constructed through gravelly textured soils with a rapid natural drainage capacity will require less extensive drainage control measures than roads through fine-textured materials.

Machinery and materials should be obtained prior to construction so that delays will be minimized. This includes a sufficient number of culverts large enough to accommodate anticipated peak flows. The location, size, and type of culvert should be marked on the road layout plan given to the operators.

Recently constructed drainage systems should be checked during and after a heavy rain to determine whether control measures are adequate, and problems should be corrected.

Roads should be crowned so that water flows into the ditches rather than running down the road.

Ditch discharge should be directed onto stable slopes, or rip-rap, to prevent erosion and, on seldom used temporary roads, dips or water bars may be used for drainage and erosion control (Fig. 3.3). These must be close enough together so that the amount of water collected will be small enough to be easily diverted. Appropriate spacing of water bars on various slopes in different soils is given in Table 3.2. These intervals are approximate and should be modified to avoid diverting water onto deep fills or unstable natural slopes. Water bars should be skewed to allow water to drain downhill across the road. Water bars should be installed at the end of each field season along the road network.

3.2.3 STREAM CROSSINGS

Stream crossings should be considered early in the planning stage so that problems can be identified and solved before they occur.

Any work that results in the harmful alteration, disruption, or destruction of fish habitat is an offence under the Federal *Fisheries Act.* Any activity in and around watercourses should therefore be kept to a minimum.

The timing of construction of crossings is important. Some streams will contain fall spawners such as kokanee, and the eggs in the gravel will be susceptible to sedimentation over winter. Some streams will contain spring spawners, such as rainbow trout, and undue turbidities will cause egg and alevin mortality until mid-summer. Late summer work in permanent streams may offer the advantage of encountering spawning areas barren of eggs, and low water levels which will allow much work to be done in the dry.

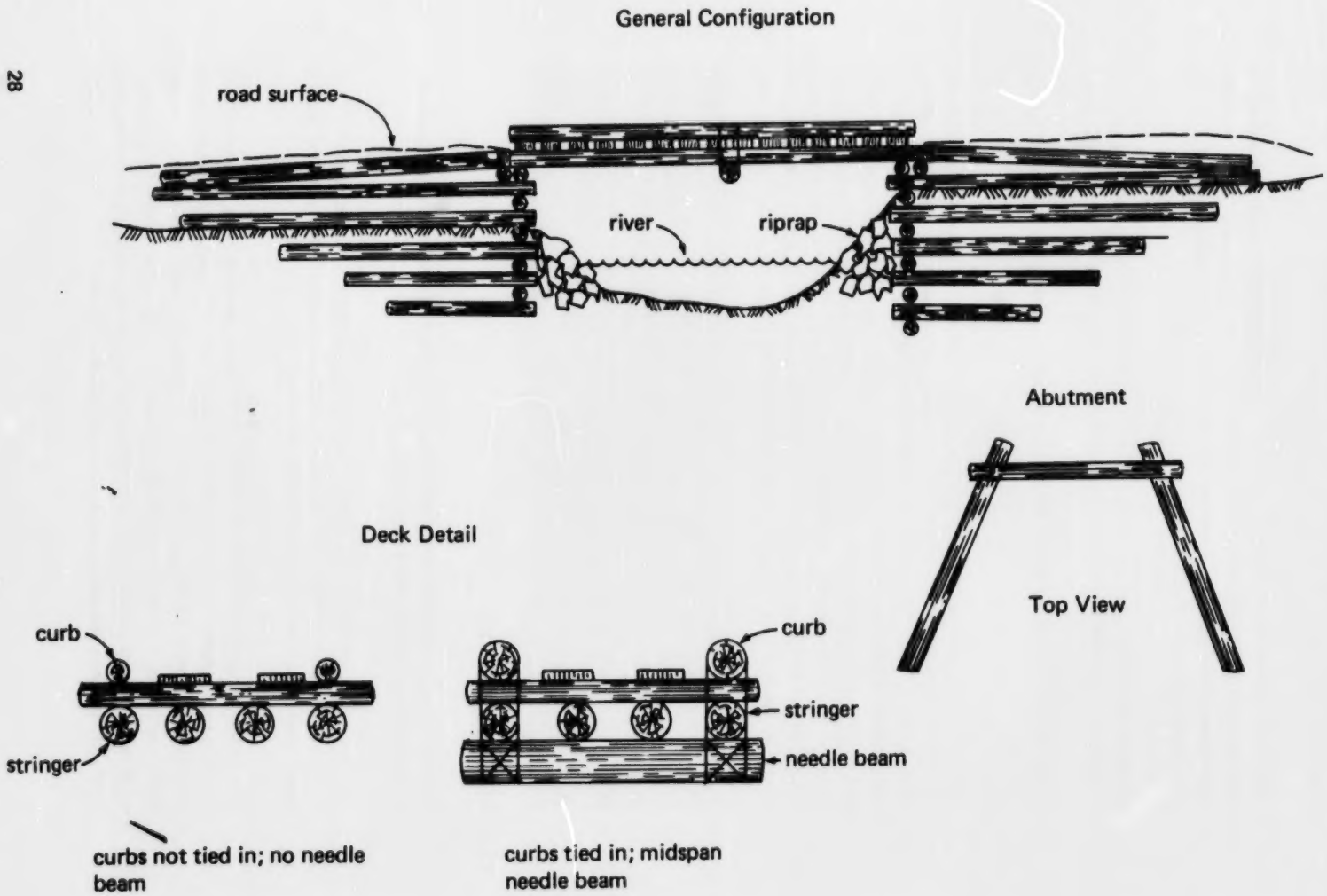


Figure 3.4. Simple bridge design for use on larger channels.

Upon completion of a crossing structure, all debris should be removed from below the high water mark since it may enter the stream during heavy runoff.

Bridges

Bridge crossings should be used both on large streams and those supporting fish populations. Properly constructed bridges do not alter stream flow characteristics or stream habitat.

Debris bridges should not be used as they contravene both the *Fisheries Act* and the *Water Act.*

A plan for a simple log bridge suitable for crossing a small stream is given on Figure 3.4. This bridge can be built of local materials, perhaps utilizing trees felled during road clearing. Large bridges should be engineered and built by personnel familiar with bridge construction.

There are several commonly occurring problems associated with bridge construction. These can be avoided by:

- rough-notching all crib joints to improve seating and reduce the spacing between logs. Some blocking may be necessary to prevent backfill from spilling out during floods, as loss of crib filling will lead to bridge failure. Coarse gravel or cobbles may be used to fill cribs as this material is less likely to erode between the logs (Fig. 3.5).

Figure 3.5. Bridge across stream with high fisheries values. Note coarse rock used on abutments as a crib filling.

- constructing bridge spans that are long enough. Many failures have occurred because of erosion caused by abutments that were extended too far into the stream channel.

- constructing the bridge so that water will be able to flow around the structure via the old backwater channels in case of a large flood, that is, using low approaches.

Culverts

Culverts increase water velocity and may obstruct fish passage. Proper design of large culverts to allow for maximum anticipated flows and safety against erosion, as well as fishery requirements, may require engineering input. Culvert crossings, therefore, are only recommended for smaller streams.

Hanging outfalls should be avoided. These may be caused by improper installation or by erosion at the outlet. The latter cause may be eliminated by covering the channel below the culvert with rip-rap.

Needless increase in water velocity may be prevented by installing the culvert at existing stream gradient. Culverts may have to be installed deep enough in the existing bed to allow a sufficient depth of water in the culvert to permit fish passage.

Fords

The use of fords as stream crossings has advantages where little traffic and a shallow boulder stream bed occur. The permission of the Fish and Wildlife Branch should be obtained.

3.3 DRILLING

Generally speaking, the impact of drilling alone is quite small and can be minimized if proper planning and construction procedures are used.

Although the location of a drill pad is dictated by the geological stratification, slight relocations are often possible to avoid problem areas. Drill sites should be located away from unstable slopes, steep terrain, wet areas, or stream banks, as this will significantly increase construction and reclamation difficulties.

The smallest possible drill pad area should be used. Trees should be felled and bucked according to slashing guidelines.

Topsoil and overburden should be removed from the drill pad area and stockpiled for use in reclamation when the site is abandoned.

A sump pit should be excavated to accommodate any waste drill fluid. Waste drill fluid must not be discharged into water bodies.

At the completion of drilling, the site should be resloped and revegetated according to the site preparation and revegetation guidelines (Chapter IV— Reclamation).

If during drilling operations, any underground water is released and flows to surface, the drill hole location must be immediately reported to the Inspection and Engineering Branch. If, in

the opinion of an Inspector, the flowing hole is creating an environmental hazard, the hole shall be cemented or otherwise plugged to prevent the flow of water.

Any drill hole which penetrates a seam of coal which may be worked by underground methods at any time in the future, or which may have approached a position where it could affect the safe working of any such seam, shall be sealed throughout its length in the manner contained in instructions issued by the Chief Inspector.

3.4 TRENCHING

Bulldozer trenching in coal exploration has, in the past, caused significant surface disturbance. The present guidelines are aimed at reducing this impact:

- For all trenching programs, preplanning is necessary to identify trench sites that will give the greatest amount of information with the smallest amount of disturbance.

- In all cases, trenches should be located at right angles to the strike, that is, avoid seam tracing. Trenches (except hand trenches) planned for slopes steeper than 2:1 require specific permission of the Ministry of Energy, Mines and Petroleum Resources' Inspection and Engineering Division.

- Overburden, to the depth of rooting, must be removed prior to trenching and stockpiled for use in resloping. Material should not be shoveled down hill. After geological work has been completed and before the end of the season, the trench must be backfilled with overburden and the topsoil spread over the surface.

Three methods of trenching are presently in use.

Hand Trenching

The major advantage of hand trenching is that road access to the trench site is not necessary. This greatly decreases the disturbed area and allows trenching on sites that are not accessible by machine. Because the trench itself is small and disturbance is limited, requirements for backfilling and reclamation are greatly reduced (Fig. 3.6).

Hand trenching can provide substantial savings in cost. It has been estimated that costs per unit information gained by hand trenching are about **one tenth** of the costs of trenching with machinery.

Hand trenching is, however, restricted to relatively shallow trenches and may prove unsuitable in hard or frozen ground.

Backhoe Trenching

The backhoe was designed as a trenching tool and is very efficient when used for this purpose.

Backhoe trenches are usually quite narrow and thus cause little disturbance. Topsoil and overburden are easily removed and stockpiled adjacent to the trench for use in resloping (Fig. 3.7). The 'hoe,' a small bulldozer, or a skidder may be used for backfilling and site preparation.

Figure 3.6. Hand trenching on areas of shallow overburden.

Figure 3.7. Backhoe being used for backfilling and site preparation.

Backhoe trenches greater than 1.5 metres deep must have their walls sloped back or be provided with adequate structural support to prevent collapse. A cage-type apparatus made of steel pipe and screen has been used successfully in the northeast. The cage was 2 metres long, 2 metres high, and 0.5 metre wide and open at both ends with a slit along one side so that the geologist could reach out. It was lowered into and moved along the trench with the backhoe boom.

Road building, and its associated cost and disturbance, may be reduced in trenching operations by employing all-terrain vehicles with backhoe attachments. Removable backhoes are available for small bulldozers, skidders, and tracked A.T.V.'s. Also available is a 'climbing backhoe,' a highly specialized machine with limited application. In many cases, these machines require only minor clearing and can save extensive road construction. The choice of equipment will depend largely on terrain and the degree of mobility required.

Bulldozer Trenching

Bulldozer trenching in coal exploration is not permitted except with the specific permission of the Ministry of Energy, Mines and Petroleum Resources' Inspection and Engineering Division.

Where bulldozers are used for trenches, work must be carefully controlled to minimize disturbance and to ensure that material is not pushed down slope. Bulldozer trenching has a far greater impact than either of the alternatives. It is recommended that bulldozers be considered only in areas where trenching by hand or backhoe is not possible.

3.5 ADITS

Adit construction can present difficult erosion control and reclamation problems. Planning and careful supervision are required to reduce the area of disturbance and ensure that reclamation is possible. **All adit site locations must be inspected and approved by the Ministry of Energy, Mines and Petroleum Resources' Inspection and Engineering Branch prior to construction.** Site specific instructions will be given.

Adits placed on slopes greater than 26 degrees (2:1) are more susceptible to erosion and are more difficult to revegetate than those constructed on flatter slopes. Therefore, two sets of construction guidelines are presented below.

Adits Constructed on Slopes Less Than 26 Degrees (2:1)

- Topsoil and overburden to be stripped from the excavation site and stockpiled separately in a safe location.
- Coal waste to be stockpiled on the adit platform.
- After use of the adit has been completed, the excavation to be backfilled and recontoured to a slope of 26 degrees (2:1) or less. Waste coal should be deposited first so that it can be covered with overburden as deeply as possible. Overburden to be replaced and topsoil spread over the surface (Fig. 3.8). The site then to be revegetated according to procedures described in Chapter IV, Reclamation. Drainage control measures to be sufficient to avoid erosion of the backfilled area.

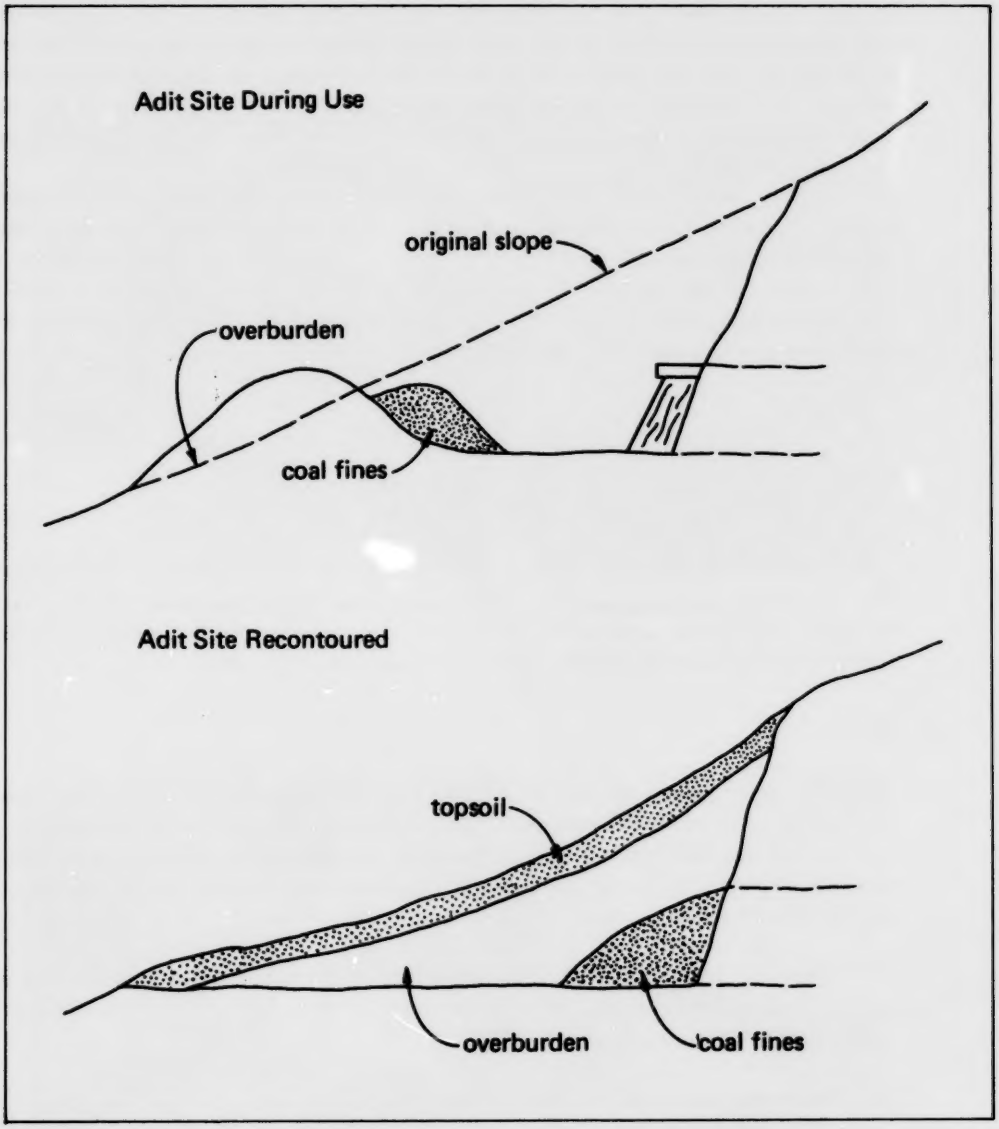


Figure 3.8. Adit design and recontouring on sites less than 26 degrees.

Adits Constructed on Slopes Greater Than 26 Degrees (2:1)

- Topsoil and overburden to be removed from the excavation site and stockpiled separately in a safe location.
- Preparation of the adit platform to be full bench construction (Fig. 3.9). **Under no circumstances should material be pushed down slope.**

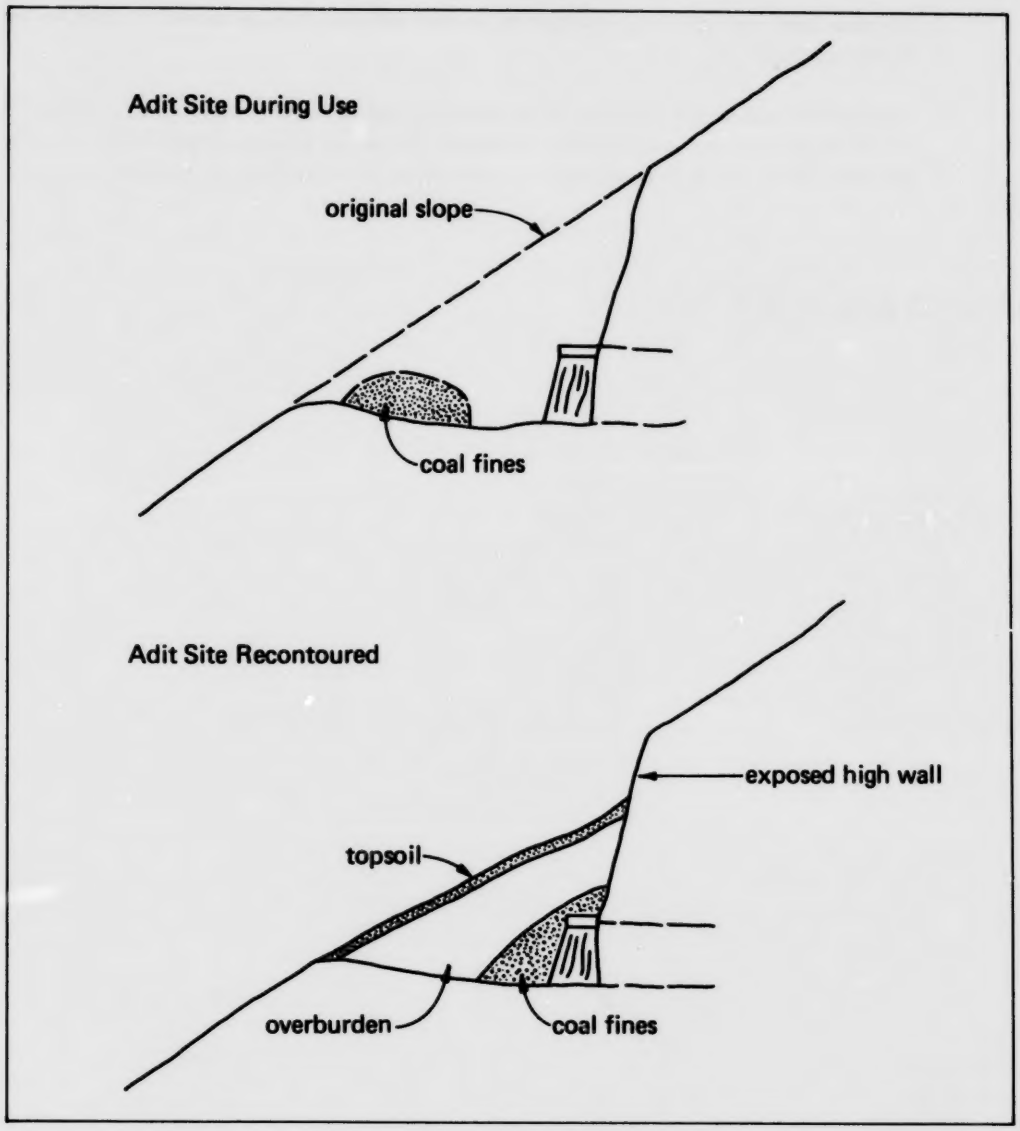


Figure 3.9. Adit design and recontouring on sites greater than 26 degrees.

Overburden pushed downhill oversteepens and destabilizes the surface, leading to accelerated erosion and extreme difficulties in revegetation. Steeply sloping coal fines present a major problem as they are highly erodible and a poor growth medium for plants.

In many cases, coal waste can be stockpiled on the adit platform. If this is not possible, coal waste should be hauled to a level site, buried, and covered by a layer of overburden or topsoil.

After use of the adit has been completed, the excavation is to be backfilled and recontoured to a slope of 26 degrees (2:1) or less. This may entail leaving a portion of the highwall exposed. Waste coal (if not disposed in a separate pit) should be deposited first and covered by overburden and topsoil.

On these steep sites it is very important to establish adequate drainage control to avoid erosion of the backfilled area.

Adits which must be left open for further sampling shall be sealed to prevent entry (section 14 of the *Mines Act*), and provided with a means to relieve any buildup of water pressure inside the adit. Waste coal is to be covered and the adit platform reclaimed as described previously.

IV.

RECLAMATION

IV. RECLAMATION

4.1 GENERAL

The current requirement for reclamation of exploration areas is stabilization and revegetation of all areas. Both the stability and vegetation cover should be permanent. To achieve this the following should be done by the end of each field season:

Campsites

- Campsites which are to be abandoned shall be dismantled at the end of operations. All refuse shall be burned and buried. Sump pits shall be backfilled. The site shall be ripped, if necessary, to break surface compaction and revegetated.

- Campsites which are to be left during winter for reuse the following season shall be cleaned up. All refuse shall be burned, buried, or removed.

Trenches, Adits, Drill Sites, and Major Excavations

- All trenches shall be backfilled and adits, drill sites, and major excavations shall be recontoured as nearly as possible to the previously existing slopes and revegetated. Work which is required to be left open for the following year will be identified to the Reclamation Inspector at the final inspection. Highly erodible material, such as fine coal shall be buried in the excavation. Overland drainage shall be conducted around disturbances.

- Many sites require little work apart from some 'cleaning up' and spreading of overburden. Depressions and small pits should be filled and any piles of soil or wood debris spread out. Stockpiled topsoil should be leveled over the site and then smoothed over by backblading or running a bulldozer back and forth over the surface.

Roads

It is important to identify those roads which can be abandoned and those roads which are necessary for future exploration. Roads that will not be used the following field season should be treated as abandoned. Some portions of the road system may be required by the Ministry of Forests for permanent fire access. It is in the operator's interest to contact the Ministry of Forests in this regard.

All abandoned roads should have a system of permanent erosion control, with erosion bars placed at frequent intervals to ensure stability.

All abandoned roads above the treeline should be recontoured by leveling the berms over the road surface. Berms generally contain the topsoil and overburden that were removed during construction and the 'pulling back' of this material will greatly assist in establishing permanent vegetation without maintenance fertilization programs. Removing the berms also allows water to drain directly from the road helping reduce gully erosion. Total recontouring may be required on grasslands or other highly sensitive areas.

Abandoned roads below the treeline will require recontouring only for the purpose of erosion control although drier sites would benefit from a surface dressing of topsoil.

All abandoned roads should be ditched or blockaded at their junction with permanent roads to prevent public access.

Abandoned roads that were heavily used should be ripped to a depth of at least 0.5 metre to break compaction and to produce a more suitable seed bed.

4.2 SITE PREPARATION

The most useful machine for recontouring and general reclamation is a small bulldozer (D3 or D4 Caterpillar, Case 450, John Deere 450, etc.). Bulldozers are available with angling and tilting blades allowing greater flexibility and may be fitted with a five-shanked ripper-scarifier for breaking compaction. Many of these machines will take, in place of the ripper, a small backhoe which is suitable for trenching, installing culverts, and maintaining ditches. These hoes are often easily removed when not required.

On steep sites where a high degree of recontouring is required, bulldozers tend to increase rather than reduce disturbance. Under these conditions, track-mounted excavators (such as a Gradall) are more efficient and economical. Depending on the type of machine, bucket size, and soil conditions, the production of these machines in recontoured road length can be expected to range from 30 to 60 metres per hour.

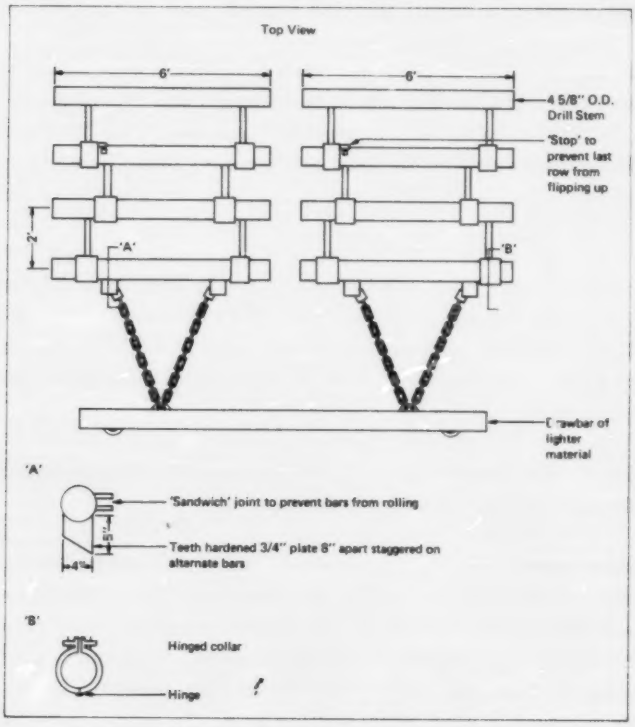


Figure 4.1. Design of simple pipe stem harrow.

Excavator production is greatly reduced by slash incorporated in the road bed. One excavator attachment which is very useful in forested areas is the 'wrist-o-twist' bucket. This device allows the bucket to swivel and makes it possible to reach around and behind trees to remove fill.

To break the surface on slightly compacted roads a pipe stem harrow may be used. These may be inexpensively constructed from drill stem, and a suggestion design for a harrow 4 metres (12 feet) wide is enclosed (Fig. 4.1). One 2-metre (6-foot) section can be used behind a small bulldozer.

4.3 REVEGETATION

This section outlines revegetation treatments for the 'normal' situation. Recommended seed mixtures are based upon the best available knowledge at this time. There is no guarantee that these treatments will be 100 per cent effective.

All areas required to be stabilized and revegetated before return of the security bond and the operator should be prepared to reseed unreclaimed areas. Revegetation prescriptions are given for all areas of British Columbia on Figure 4.2 and in Appendix D, and particular reference to

Figure 4.2. Regional map to be used in conjunction with appendices E and F to determine the prescribed reclamation treatments.

the Peace River and Crowsnest coal blocks is made below. In all instances revegetation treatments require seed mixture and fertilizer applications. A visual approximation of various seeding rates is given on Figure 4.3. The seed mixtures in Appendices D and E often contain

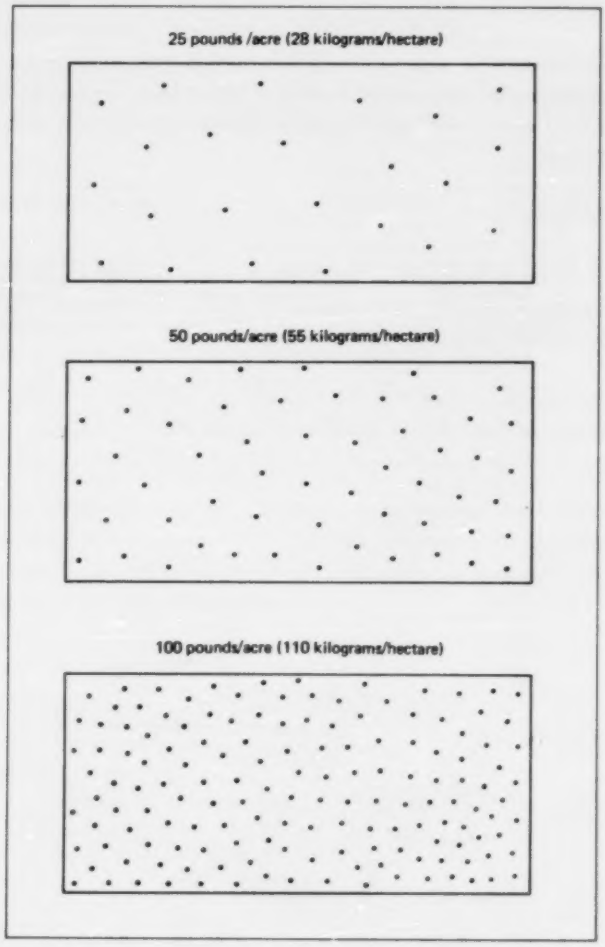


Figure 4.3. Approximate ground cover for various seeding rates.

species that cannot be obtained locally and must be ordered from major seed suppliers in Vancouver. Check availability of seed mixes locally before commencing surface work.

The time of seeding is important in some areas of the province. Poor success results when, following germination, frost or drought occurs.

All seeding should take place during the early spring, or fall. Spring seeding gives plants a complete growing season to become established, while fall seeding allows seed to over-winter before germinating the following spring. Species seeded in the alpine between July 20 and August 31 may begin to germinate but will have a high mortality rate with the onset of early fall frosts. Seeding during this period, therefore, is usually a waste of time and money.

Seeding during or immediately after rain will increase revegetation success because seed germination is assisted by moist soil conditions.

A fertilizer application should accompany seeding. If not, germination and growth will be poor and the area may require subsequent seeding and fertilization. A 'complete' fertilizer formulation such as 20-20-10 should be applied. In the three digit fertilizer description, the first number refers to the number of kilograms of nitrogen contained in 100 kilograms of fertilizer. Similarly, the second and third numbers refer to the number of kilograms of phosphorus (P_2O_5) and potassium (K_2O), respectively, contained in 100 kilograms of fertilizer.

Thus:

450 kg/ha of 20-20-10 gives (400 lb./acre)	90 kg/ha N* 90 kg/ha P_2O_5 45 kg/ha K_2O
560 kg/ha of 13-16-10 gives (500 lb./acre)	73 kg/ha N 90 kg/ha P_2O_5 56 kg/ha K_2O

If a single complete fertilizer is not available, two or more can be used to supply the required rate of each nutrient.

400 kg/ha of 16-20-0 (400 lb./acre) plus 65 kg/ha of 0-0-60 (60 lb./acre)	64 kg/ha N 80 kg/ha P_2O_5 39 kg/ha K_2O

*Metric conversions:	1 acre	= 0.4 ha
	1 lb.	= 0.45 kg
	1 lb./acre	= 1.12 kg/ha

The major drawback to using two fertilizers is that they must be applied separately because they are difficult to mix accurately.

All seeded and fertilized areas should be lightly harrowed to bury seed to ensure adequate germination and survival.

Fertilizer can be purchased at most major centres in British Columbia. Availability should be checked before surface work is started.

4.3.1 CROWSNEST COALFIELD

Exploration in the Crowsnest Coalfield generally takes place below treeline, avoiding the difficult reclamation problems of the alpine zone. Although revegetation is straightforward in most cases, two seed mixes have been developed by B.C. Coal (formerly Kaiser Resources Ltd.) to ensure better success at high and low elevations. This experience has assisted considerably in development of the treatments given in Appendices D and E.

4.3.2 PEACE RIVER COAL BLOCK

In the Peace River coal block there are two distinct situations that require different treatment for revegetation – areas above treeline and forested regions.

Areas Above Treeline

- 'Areas above treeline' are defined as those areas generally occurring above the 1 370-metre (4,500-foot) contour where tree growth is absent and/or where trees become stunted or deformed (Krummholz). These areas are often referred to as alpine or high subalpine. They are characterized by short cold growing seasons and high wind velocities. Revegetation is very difficult.

- It is important to salvage surface soils and then recontour and harrow before seed and fertilizer are applied.

Forested Regions

- Generally disturbance in forested areas pose few revegetation problems provided the site is recontoured and stabilized. Seeding can be done at any time during the year although the best times are early spring and fall.

- Applications of fertilizer are normally not required in the forested region. However, rocky or gravelly areas, where topsoil salvage has not been possible, must receive a fertilizer application identical to that recommended in areas above treeline.

- Seeding should be carried out in the early spring or late fall to avoid dry summer conditions. Fall seeding should take place late enough so that seed does not germinate until the following spring.

4.4 REVEGETATION METHODS AND EQUIPMENT

Seeding

Broadcasting is the simplest and least expensive method of seeding. In this technique, seed is simply scattered over the surface of the ground by hand or with the aid of various seeding devices. On most projects, hand-held cyclone seeders are used to disperse seed, although seeders mounted on all-terrain vehicles, bulldozers, and tractors are being used more often. The technique of broadcast seeding from helicopters or fixed-wing aircraft has been used successfully in a number of areas but may be more applicable to extensive waste dumps or powerline rights-of-way than to exploration disturbance.

The major drawback to broadcast seeding is that it is very difficult to obtain the desired uniform seed spread during windy weather. This is a problem in many parts of the coal areas, especially the alpine areas where high winds are prevalent.

Hydroseeding of exploration areas has been used less extensively than broadcasting. In this technique a slurry composed of seed, fertilizer, mulch (or soil stabilizer), and water is pumped through a nozzle and sprayed over the ground (Fig. 4.4). There are a wide variety of mulches

Figure 4.4. Hydroseeder in operation on a coal exploration area.

(the most commonly used being fiber mulches) and soil stabilizers available. Fiber mulches are generally made from wood products and are composed of cellulose fibers which disperse in water. These mulches are often combined with a binder. When sprayed on the soil surface, fiber mulches (and binders) have some soil stabilizing capability and absorb water to provide better conditions for seed germination. Chopped straw has been used successfully as a fiber mulch with an asphalt binder. Soil stabilizers are applied in liquid form and are generally composed of natural or synthetic polymers which bind the soil particles together. These compounds generally do not affect the germination conditions but are designed to prevent surface erosion until a cover of vegetation has become established.

The major drawback to the use of hydroseeding in reclamation of exploration areas is the high transportation cost of equipment and materials, particularly in remote areas. In addition, a water tank truck may be required if an ample water supply is not available at the reclamation site.

Burying Seed

Anyone who has been involved in reclamation will have observed the 'cat track' phenomenon where grass is growing best in old bulldozer cleat marks. This occurs because seed is washed into small depressions and covered with soil, producing growing conditions far better than those on the bare surface. On soft sites, the success of revegetation can be greatly increased by running a caterpillar up and down the slope to cover the area with cleat marks. On hard ground or in difficult dry or alpine sites, it is better to harrow the ground both before and following

seeding (Figs. 4.5 and 4.6). The design of a simple drillstem harrow that can be pulled behind a small bulldozer was given at the beginning of this chapter.

Figure 4.5. Small bulldozer towing pipe stem harrow.

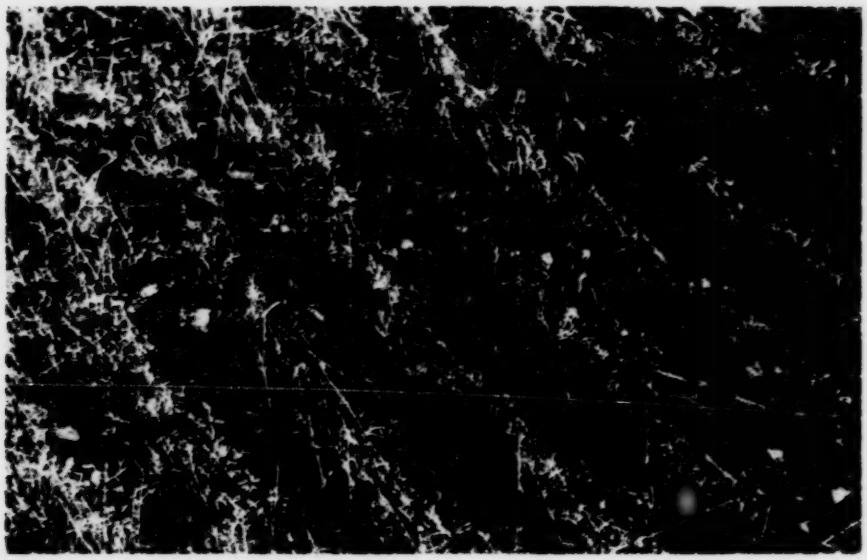


Figure 4.6. Seed growing on a site that was harrowed.

Seed can be buried by dragging a heavy bar with loops of chain welded to it. If seeding is done from a vehicle, this bar can be towed at the time of seeding.

4.5 REVEGETATING WITH SHRUBS

4.5.1 CHARACTERISTICS AND USES

Revegetating with the use of native shrubs has been carried out experimentally in the southeast for a number of years. Most of the work has been done on waste dumps in conjunction with operating mines but the same techniques may be applied to exploration disturbance.

Shrubs have a number of characteristics that make them valuable in reclamation work, especially when used with a grass/legume seed mix.

Erosion Control

- Shrubs have deep woody roots which give mechanical support to slopes. Seeding with grasses alone often forms a shallow layer of sod which reduces surface erosion. Unfortunately, on steep slopes, under very wet conditions, the entire sod layer may slough off. Shrubs planted or seeded along with the grass can help to avoid this type of problem. The extensive, woody top growth of shrubs can significantly reduce the surface wind velocity, along with its associated erosion.

Wildlife Habitat

- Shrubs provide a good source of food and protective cover for wildlife. Ungulates make use of many species of shrubs as browse, especially during winter when other food sources are buried beneath the snow.

Aesthetics

- To spend time and money making an area 'look good' seems somewhat impractical but the greatest bulk of public opinion is swayed by the way an area looks. Shrubs are very useful in screening areas of activity from public view and for softening the harsh lines of disturbed sites.

Shrubs can be grown either from seed or from cuttings. Most of the work on shrubs for reclamation in British Columbia has used nursery facilities to grow seedlings or root cuttings for eventual planting at the reclamation site. Unfortunately, this type of facility is beyond the scope of exploration projects. Coleman Collieries, however, has grown black cottonwood cuttings, directly on waste heaps without prior rooting in a nursery (Fig. 4.7). This type of work, collecting cuttings from the surrounding area for planting on an adit or trench site, is certainly within the realm of any reclamation program. The following section describes principles and techniques used in the growth of the shrubs from cuttings as applied to small reclamation projects.

4.5.2 SELECTION

The following factors should be considered in choosing shrubs for use in a revegetation project.

Figure 4.7. Black cottonwood cutting planted directly on a disturbed site.

- Shrubs used in revegetation work should be 'pioneer' species. These are plants specifically adapted to invading an area after disturbance. They are tolerant to low nutrient and moisture conditions and can withstand the bright sunlight and harsh temperatures experienced on a disturbed site. The best way to identify pioneer species is to look at areas of old disturbance near the site of the proposed project. The plants growing on these sites will have the greatest chance of success as reclamation species.

- Shrubs should be planted in areas with similar climatic conditions to the areas where they were originally grown. As a rule of thumb, seedlings should be planted within 166 metres (500 feet) elevation of where they were originally grown.

- The influence of aspect (direction of slope) should be considered before planting. Shrubs growing on northern aspects are, in most cases, adapted to moist, cool conditions and would grow poorly on dry, south-facing slopes. Similarly, seedlings grown on southern aspects would have poor success on north-facing slopes. In general, however, if shrubs are taken from areas with natural vegetation similar to that adjacent to the planting site, this type of problem can be avoided.

4.5.3 PROPAGATION

There are a number of different procedures for taking cuttings from the stems and roots of shrubs. The techniques described are quite precise and are designed for the greatest possibility of success. They are not, however, the 'final word' and the best methods for different species in different areas must be determined by experimentation.

Hardwood Stem Cuttings

Hardwood cuttings may be taken during the autumn or early spring from dormant shoots of deciduous species from the past year's growth. The cuttings should be 15 to 20 centimetres long with the lowest cut 2 centimetres below a bud and the upper cut 2 centimetres above a bud. They should be planted vertically in the soil with the upper bud slightly above the soil surface.

Softwood Stem Cuttings

Softwood cuttings should be taken from leafy slips of the present year's growth of deciduous species. They should be 10 to 15 centimetres long with all but the top few leaves stripped off. The cuttings should be planted with the lowest leaf about 3 centimetres above the soil surface. The leaves stimulate rooting but can lead to the drying out of the cutting. In nurseries, these types of cutting are usually shaded in a cold-frame or polyethylene tent. This will not be possible in an exploration reclamation program so this method should only be used on moist or shaded sites.

Evergreen Stem Cuttings

Evergreen cuttings (from broadleaf evergreen and coniferous species) should be treated in the same way as softwood cuttings but must be prepared and planted in the early fall, after the first frosts. Cuttings may be taken from coniferous species such as juniper or from broadleaf evergreens such as kinnikinnik. Pine, fir, balsam, and spruce do not root well.

Root Cuttings

Root cuttings may often be taken from shrubs which have been uprooted by construction. They should be taken from young roots, about pencil thickness and cut into 5 to 8-centimetre lengths. Cuttings should be planted 5 to 8 centimetres deep either horizontally or vertically with the cut end nearest the stem uppermost. This end will sprout and grow new stems.

The successful rooting of stem cuttings can be aided by wounding the base of the stem. This wounding may be by crushing or cutting with a knife so that the bark is broken in a number of places. The wounded area can then be treated with a rooting hormone to stimulate root initiation. Powdered hormone preparations are commercially available under names such as 'Rootone' and 'Seradix.'

APPENDIX A

LEGISLATION

APPENDIX	DESCRIPTION
A–1	Sections 6, 7, 8, and 9 of the *Mines Act*
A–2	Coal Exploration Forms:
	Notice of Work on a Coal Licence
	Reclamation Program
A–3	Addresses of Regulatory Agencies

NOTE

The *Mines Act* will soon replace the *Coal Mine Regulation Act.* Nothing of significance has altered in the wording or intent of these sections. Copies of the amended act will be available shortly at the offices of the District Inspectors.

Work system approvals

6. (1) The owner, agent or manager shall give notice to the inspector of intention to commence work on, or to stop work in or about a mine, and, except in an emergency, the notice shall be not less than 7 days.

(2) No work, other than surface exploratory work in mines that are not coal mines, shall be commenced without the written approval of the chief inspector.

(3) Before opening or beginning to open or develop a mine, the owner, agent or manager shall file with the chief inspector a report and plan of the system suitable to the chief inspector under which it is proposed to work the mine.

(4) The owner, agent or manager shall not depart from the plan of the system to any substantial degree without the written approval of the chief inspector.

(5) The plan of the system shall

(a) be prepared taking into consideration the safety of the public and persons involved in the work,

(b) be designed so as to make it as practicable as possible in the future to mine zones affected by the plan, and

(c) in relation to a coal mine, provide for maximum possible recovery of the resources having regard to sound engineering practice.

Reclamation of surface

7. (1) The owner, agent or manager shall file with the minister a program for the protection and reclamation of the surface of the land and watercourses affected by the mine in a form and containing the information the minister may require before commencing preparatory work for production from a mine, and the program must include the particulars and maps that may be prescribed.

(2) Notice of the filing of the program under subsection (1) must be published, by the person filing it, in the Gazette and in those newspapers specified by the minister.

(3) A person affected by or interested in a proposed program submitted under this section may, within 30 days after the last date on which a notice is published under this section, make written representations to the minister.

Reclamation Advisory Committee

8. (1) A Reclamation Advisory Committee is established consisting of the chief inspector as chairman and other persons appointed by the minister.

(2) The minister shall submit the program and representations received by him under section 7 (1) and (3) to the committee which shall study them and make recommendations to the minister.

(3) After considering the recommendations of the committee and any representations made to him under section 7, the minister shall, within 60 days after the last date on which the notice referred to in that section is published,

(a) approve the program,

(b) reject the program, or

(c) after revising or amending the program, approve it in its revised or amended form,

and, where he approves a program, he shall issue a permit authorizing the work subject to compliance with the program.

(4) A permit issued under this section may contain conditions, including conditions pertaining to the future implementation of the program.

Security

9. (1) It is a condition of a permit issued under section 8, that the owner, agent or manager of a mine shall deposit as security with the Minister of Finance an amount the minister determines, but not exceeding $2 500/ha of land used or to be used for the mine and the waste disposal of the mine as set out in the approved program.

(2) The security shall be held by the Minister of Finance as security for the proper performance by the owner, agent or manager of the approved program and all the conditions of the permit in a manner satisfactory to the minister, and the security may be used, on requisition of the minister, for the purposes of subsection (6).

(3) During the entire period of production from a mine, the owner, agent or manager shall

(a) continually and progressively reclaim the surface of the land affected by the mining operation in accordance with the approved program, and

(b) if required by the minister, deposit as security in a form satisfactory to the minister, in each year, an amount that, together with the deposit under subsection (1) and calculated over the estimated life of the mine, will provide the money necessary to perform and carry out properly

(i) all the requirements of the approved program at the proper time, and

(ii) all the orders and directions of the chief inspector or an inspector respecting the execution of the approved program.

(4) If a dispute arises respecting an order or direction of the chief inspector or an inspector under subsection (3), the owner, agent or manager may appeal in writing to the minister and the minister shall, after affording the parties the opportunity of a hearing, decide the appeal.

(5) The owner, agent or manager, or an inspector, may apply to the minister for revision of the conditions of the permit issued under section 8, and, following a recommendation of the Reclamation Advisory Committee, the minister may revise the conditions.

(6) Where the owner, agent or manager fails to perform and complete the program for reclamation and the conditions of the permit in a manner satisfactory to the minister, the minister may apply all or a part of the security toward payment of the cost of the work required to be performed and completed.

(7) On the completion, discontinuance or abandonment of a mining operation, and on the minister being satisfied that this section has been complied with and that the approved program has been properly completed, the person who deposited the security is entitled to a refund of it, less any amount paid out under subsection (6).

APPENDIX A–2

COAL EXPLORATION FORM 6

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

MINERAL RESOURCES DIVISION
INSPECTION AND ENGINEERING BRANCH

NOTICE OF WORK ON A COAL LICENCE

(Sections 6 and 28 of the *Mines Act*)

This notice is to be completed by all companies or individuals carrying out exploration work prior to commencement of work and at cessation of work and forwarded to the following: Chief Inspector of Mines, Victoria, and Inspector of Mines and Resident Engineer for the District. If mechanical equipment is used in surface work, Form 7 overleaf must be completed.

1. NAME OF PROPERTY .....

   Coal Licence Numbers .....

   .....

2. LOCATION ..... NTS map sheet no. .....

   Lat. .....° ..... ' Long. .....° ..... ' Access via .....

   .....

3. OWNER'S NAME .....

   Address ..... Telephone no. .....

4. OPERATOR'S NAME .....

   Address ..... Telephone no. .....

5. ESTIMATED DURATION OF WORK: From ..... to .....

   OR: ACTUAL DATE WORK COMPLETED: From ..... to .....

6. DESCRIPTION OF WORK (Use metric measure – 1 metre = 3.3 feet.) (Show on 1:50 000-scale map.)

   Linecutting (distance, width, method) .....

   Clearing of timber .....
   (requires approval of Ministry of Forests. 'Licence to Cut' or 'Free Use Permit' may be withheld until reclamation program is approved.)

   (a) **Road Construction**: Total length ..... m Approximate width ..... m Area ..... m^2

   (b) **Test Pits**: No. ..... Maximum dimensions: Width ..... m Length ..... m Depth ..... m

   Sum total length ..... m Total disturbed area of test pit ..... m^2

   (c) **Drilling**: No. of DDH ..... Size ..... No. of RDH ..... Size ..... Max. hole length .....

   Sum total depth ..... m Total disturbed area of drillsites ..... m^2

   Down hole geophysics: types .....

   Were all holes recorded and sealed in compliance with Chief Inspector's instructions? Yes ☐ No ☐
   An explanation must be given if the answer is no.

   (d) **Adits**: No. rising at .....° is ..... No. level ..... No. dipping at .....° is .....

   Maximum length of adit ..... m Total disturbance .....

   Sum total length .....

   (e) **Trenches**: No. ..... Maximum dimensions: Width ..... m Length ..... m Depth ..... m

   Sum total length ..... m Total disturbed area of trenches ..... m^2

   (f) **Other** (for example, please specify underground work): .....

   .....

   (g) Indicate location and scale of any mapping done .....

   .....

   GRAND TOTAL OF AREA DISTURBED ..... ha

   (h) Approximate number of men employed .....

7. OTHER: an estimate of exploration expenditure is requested to be forwarded to the Chief Inspector in Victoria, after work is complete.

SIGNATURE OF APPLICANT ..... TITLE .....

PRINT NAME ..... DATE .....

NOTE: Owner, agent, or manager is responsible for ensuring the Contractor complies with pertinent regulations [see section 27(2), *Mines Act*]. Pursuant to section 30 of the *Mines Act*, where the employment of mechanical equipment is likely to disturb the surface of the land in clearing, stripping, trenching, or any other operation, the reclamation program on the reverse side is also to be submitted.

APPENDIX A–2 *(CONTINUED)*

COAL EXPLORATION FORM 7

PERMIT NO. C .....

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

MINERAL RESOURCES DIVISION
INSPECTION AND ENGINEERING BRANCH

RECLAMATION PROGRAM

(Sections 7 and 30 of the *Mines Act*)

This form is to be completed when exploration work is done with mechanical equipment. Submission is required prior to commencement of work and at completion of work. One copy is to be sent to each of the following:

*Senior Reclamation Inspector, Victoria	Regional Manager, Ministry of Forests
*Inspector of Mines and Resident Engineer	Regional Manager, Water Management Branch
Reclamation Inspector – Technician	Regional Manager, Lands Branch
Regional Manager, Fish and Wildlife Branch	Regional Manager, Ministry of Agriculture and Food

For advice on procedure and reclamation methods, see booklet entitled, '*Guidelines for Coal Exploration*.'

1. THIS IS: A proposed reclamation program ☐ a completed reclamation program ☐.

2. PRESENT STATE OF LAND ON WHICH EXPLORATION WILL BE DONE IS:

   Canada Land Inventory (where possible) .....

   Present Land Use (ranching, timber, etc.) .....

   Type of Vegetation .....

   Access Road (present use, condition) .....

3. EQUIPMENT TO BE USED FOR EXPLORATION (List size, capacity, and number.)

   (a) ..... (d) .....

   (b) ..... (e) .....

   (c) ..... (f) .....

4. RECLAMATION EQUIPMENT TO BE USED (for example, resloping, harrowing, or specialty equipment):

   (a) ..... (b) ..... (c) .....

5. GENERAL DESCRIPTION OF PROTECTIVE MEASURES PURSUANT TO SECTION 7

   (Show work and reclamation on 1:50 000 scale map and include with full distribution noted above.) [*For proposed work programs include with submissions to Ministry of Energy, Mines and Petroleum Resources documentation on 1:10 000 (approximate scale) air photograph or air photograph overlay.]

   .....

   .....

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6. SUMMARY OF AREA DISTURBANCE AND RECLAMATION

   Area disturbed current year ..... Previous years ..... Total to date .....

   Area reclaimed current year ..... Previous years (final) ..... Total to date .....

7. RECLAMATION MANAGER'S NAME .....

   Address .....

   DATE ..... SIGNATURE .....

*When geotechnical and reclamation work have been completed for the calendar year a final reclamation report should be submitted to the three Ministry of Energy, Mines and Petroleum Resources personnel noted at the top of this form.

APPENDIX A–3

ADDRESSES OF REGULATORY AGENCIES

Ministry of Energy, Mines and Petroleum Resources

Chief Inspector of Mines	525 Superior Street, Victoria	387–3781
Senior Reclamation Inspector	525 Superior Street, Victoria	387–3781
Chief Gold Commissioner	617 Government Street, Victoria	387–5517

District Mine Inspection Offices

Fort St. John (Reclamation Inspection only)	Box 7438	785–6906
Prince George (R.A.C.R.)*	1642 Quinn Street	562–8131 (322, 323)
Kamloops	101, 2985 Airport Drive	376–7201
Prince Rupert	Court House, Box 758	624–3245
Nanaimo	2569A Kenworth Road	758–8971
Vancouver	2747 East Hastings Street	254–7171
Smithers	Bag 5000	847–4411 (237)
Nelson (Crowsnest Coalfield)	310 Ward Street (mail) 403 Vernon Street (office)	352–2211 (303)
Fernie (Crowsnest Coalfield)	Box 1290	423–6884

Water Management Branch – Regional Managers

Prince George (R.A.C.R.)	1011 Fourth Avenue	562–8131 (236)
Kamloops	301, 1959 East Trans Canada Highway	374–9717
Kelowna	1905 Kent Road	860–6280
Nelson (Crowsnest Coalfield)	310 Ward Street	352–2211 (513)
New Westminster	313 Sixth Street	525–4604
Williams Lake	202, 172 Second Avenue North	392–6261 (263)
Smithers	3793 Alfred Street, Box 3250	847–4411 (220)
Nanaimo	2569 Kenworth Road	758–3951

Waste Management Branch – Regional Managers

Williams Lake	202, 172 Second Avenue North	392–6261 (312)
Kamloops	1050 West Columbia Street	374–5981
Prince George	1011 Fourth Avenue	562–8131 (238)
Victoria	810 Blanshard Street	387–1161
Nelson	310 Ward Street	352–2211 (339)
Penticton	1880 Government Street	493–6604
Surrey	15326 – 103A Avenue	534–8822
Smithers	3793 Alfred Street, Box 3250	847–4411 (324)
Nanaimo	2569 Kenworth Road	758–3951
Fort St. John	10142 – 101st Avenue	787–1111

Fish and Wildlife Branch – Regional Managers

Prince George	1011 Fourth Avenue	562–8131 (234)
Kamloops	106, 1959 East Trans Canada Highway	374–5102
Nanaimo	2569 Kenworth Road	758–3951
Burnaby	4240 Manor Street	435–4137
Nelson (Crowsnest Coalfield)	310 Ward Street	352–2211 (492)
Smithers	3793 Alfred Street, Box 3250	847–4411
Penticton	257 Brunswick Street	493–2714
Williams Lake	Government Building, 540 Borland Street	392–6261 (371)
Fort St. John (Regional Biologist, Peace River) (R.A.C.R.)	10142 – 101st Avenue	787–1111 (208)

*Regional Advisory Committee on Reclamation

APPENDIX A–3 *(CONTINUED)*

ADDRESSES OF REGULATORY AGENCIES *(CONTINUED)*

Ministry of Forests – Regional Managers

Prince George	1011 Fourth Avenue	564–0778 (210)
Dawson Creek (Sub-office, Peace River) (R.A.C.R.)*	9000 – 17th Street	782–8195
Kamloops	515 Columbia Street	374–7741 (311)
Prince Rupert	Market Place	624–2121 (225)
Vancouver	355 Burrard Street	668–2470
Nelson (Crowsnest Coalfield)	310 Ward Street	354–4181 (225)
Williams Lake	540 Borland Street	392–6294 (202)

Ministry of Lands, Parks and Housing – Regional Directors

Prince George	1011 Fourth Avenue	563–8131 (324)
Kamloops	348 Tranquille Road	554–3144
Burnaby	4240 Manor Street	438–5344 (249)
Smithers	3793 Alfred Avenue	847–4411 (268)
Cranbrook	828 Baker Street	489–4333
Williams Lake	172 North Second Avenue	392–6261 (307)
Fort St. John (R.A.C.R.)	220, 990 – 100th Avenue	787–7766
Victoria	404, 3960 Quadra Street	479–8288
Nelson	310 Ward Street	352–2211 (330)
Nanaimo (District Manager)	200, 190 Wallace Street	753–7717
Courtenay (District Manager)	215 Court House, 420 Cumberland Road	338–1341

Ministry of Agriculture – Regional Directors

Prince George (R.A.C.R.)	Experimental Farm Site, RR 1	963–9685
Summerland	Research Station, Box 198	494–7011
Dawson Creek	1201 – 103rd Avenue	782–5931
Abbotsford	33780 Laurel Street	859–5281
Kamloops	166 Oriole Road	374–3614
Victoria	Parliament Buildings	387–5121

*Regional Advisory Committee on Reclamation

APPENDIX B

MAPS AND AERIAL PHOTOGRAPHS

APPENDIX B

MAPS AND AERIAL PHOTOGRAPHS

Maps and aerial photographs make up an essential part of the background information required in the planning and operational stages of any exploration project. Most areas of the province are covered by a variety of maps and air photographs at different scales. The following paragraphs describe the different types, their uses, and where they can be obtained.

MAPS

TOPOGRAPHIC MAPS: Topographic maps are available at scales of 1:50 000, 1:125 000, 1:250 000, and 1:500 000. They generally show: water features, contour lines, cultural features, such as place names, roads, railways, boundaries, and land status to the date of publication. They are useful for interpretation of drainage and terrain characteristics, slopes, and topographic relief.

PLANIMETRIC MAPS: These maps are drawn from vertical air photographs tied to existing ground control. They are thus, to a certain extent, uncontrolled and geographic detail may be unreliable. However, relative positions have been maintained as accurately as possible and these maps may be useful for general purpose.

Planimetric maps are available in most areas in scales of 1:15 840 and 1:31 680 and generally show all planimetric detail such as roads, water features, and lot boundaries. No contours are shown.

DEPARTMENTAL REFERENCE MAPS: Departmental reference maps show all types of land alienations such as surveyed lots and sections, applications to purchase or lease, forestry leases and licences, mining leases and licences, and all reserves. Copies available to the public show all information to date of publication and are being constantly updated. They are generally available in scales of 1:31 680 and 1:63 360.

SOILS AND LANDFORMS MAPS: These are available for many parts of the province in published or provisional form at a scale of 1:50 000. When used in conjunction with topographic maps they are useful for interpreting soil stability and construction characteristics, erosion hazard, and availability of construction material.

VEGETATION MAPS: These are available at a scale of 1:50 000 as forest cover maps over most of the province and as vegetation maps in more restricted areas. They show forest species composition as well as forest productivity.

LAND CAPABILITY MAPS: Capability maps are available for agriculture, forestry, recreation, ungulates, waterfowl, aquatics, and climate. Land capability analysis maps are also available for some areas. These maps are at scales of 1:50 000 and 1:250 000 and are useful for preplanning of field programs and identification of sensitive areas.

Topographic and departmental reference maps may be ordered from:

Director,
Surveys and Mapping Branch,
Ministry of Environment,
Parliament Buildings,
Victoria, B.C.
V8V 1X4
Attention: Map and Air Photo Sales Office

Planimetric and forest cover maps may be ordered from:

Forest Inventory Division,
Ministry of Forests,
Parliament Buildings,
Victoria, B.C.
V8V 1X4

Soils, landform, vegetation, and land capability maps may be ordered from:

Map Librarian,
Resource Analysis Branch,
Ministry of Environment,
Parliament Buildings,
Victoria, B.C.
V8V 1X4

Catalogues listing all available maps and air photographs in greater detail may be obtained from the Surveys and Mapping Branch and the Resource Analysis Branch at the preceding addresses.

AERIAL PHOTOGRAPHY

GENERAL INFORMATION

The federal and provincial governments are the major sources of air photography in British Columbia. General keys to indexes of British Columbia photography are available in a publication by the Surveys and Mapping Branch of the British Columbia Ministry of Environment entitled Map and Air Photo Catalogue.

Provincial air photographs are indexed under block photography and special projects. The bulk of photography is contained in the block system and is available in a number of scales. These scales are 1:10 000, 1:15 840, 1:20 000, 1:31 680, 1:40 000, 1:50 000, and 1:63 360. The special projects index is a guide to special air photography comprising several hundred projects of varying scales. Each special project has an individual index.

Two types of photography are available: colour or black and white. Most of the available photography is black and white. Colour photographs have been flown only over certain special projects; there is no general colour photography in British Columbia, and it is not possible to obtain a colour print from a conventional black and white photograph. Colour is very useful for obtaining ground detail and vegetation patterns.

Enlargements of the standard 23-centimetre by 23-centimetre air photograph are available from the Surveys and Mapping Branch. The largest blowup for a complete photograph is a 4x enlargement measuring 92 centimetres by 92 centimetres. Portions of a standard air photograph can be blown up to 6x enlargements. Air photograph qualities begin to decrease with blowups four times and greater.

Air photograph mosaics are available for portions of British Columbia. The *Map and Air Photo Catalogue* previously mentioned has a key showing the areas covered by these mosaics. A more detailed key showing the location of available mosaics can be obtained by stating the exact geographical reference of your area and writing to:

Director,
Surveys and Mapping Branch,
Ministry of Environment,
Parliament Buildings,
Victoria, B.C.
V8V 1X4
Telephone: 387–3174
Attention: Map and Air Photo Sales Office

ORDERING AIR PHOTOGRAPHS

Orders for air photographs should be in writing and addressed to the above.

Figure B.1 shows the form to be filled out when ordering air photographs. The flight number and air photograph number must be included. If stereoscopic cover is not required, it is only necessary to order alternative photographs along a flight line. Figure B.2 lists the prices on materials. Air photographs are printed to order and have **no returnable value.** Prepayment is required plus sales tax for orders within British Columbia. Cheques or money orders should be made payable to the Minister of Finance.

KEYS 17-21 AIR PHOTO INDEXES			$2.00
KEYS 20-21A INDEXES ON XEROX SHEETS			$ .25
CONTACT REPRINTS	BLACK & WHITE	23cm x 23cm	$2.00
	FILM POSITIVE *clear or matte*	23cm x 23cm	$3.50
	COLOUR *where available*	23cm x 23cm	$4.50
ENLARGEMENTS	BLACK & WHITE	23cm x 23cm	$ 7.50
	BLACK & WHITE	46cm x 46cm	$10.00
	BLACK & WHITE	69cm x 69cm	$15.00
	BLACK & WHITE	96cm x 96cm	$20.00
	COLOUR	46cm x 46cm	$30.00
ENLARGEMENTS *clear or matte*	FILM POSITIVE	23cm x 23cm	$10.00
	FILM POSITIVE	46cm x 46cm	$15.00
	FILM POSITIVE	69cm x 69cm	$30.00
	FILM POSITIVE	96cm x 96cm	$35.00
MOSAICS	* PHOTOGRAPHIC PAPER	per 1000cm^2	$ 3.00
	* FILM POSITIVE, *matte*	per 1000cm^2	$ 4.00
	* SCREENED FILM POSITIVE	per 1000cm^2	$ 6.00
	* DIAZO WHITE PRINTS *where available*	each	$ 3.00

* *MAPS-BC staff will quote prices for each mosaic.*

Figure B.2.

Cut out and mail

PRE-PAID ORDER FORM FOR MAPS AND AIR PHOTOGRAPHS

Your Name Date

Address

Please send me the following maps and or air photographs

Quantity	Key	Map No./Flight No.	Map Name/Photo Nos.	Unit Price	Amount

For orders delivered in B.C. add sales tax _____

Add Roll Fee if maps desired rolled _____

total remittance enclosed _____

Address orders to:
MAPS-B.C.
Surveys and Mapping Branch,
Ministry of Environment,
Parliament Buildings,
Victoria, British Columbia
V8V 1X4

MAIL ORDERS HAVE NO RETURNABLE VALUE
Prices are subject to change without notice

Cut out and mail

Cut out and mail

PRE-PAID ORDER FORM FOR MAPS AND AIR PHOTOGRAPHS

Your Name Date

Address

Please send me the following maps and or air photographs

Quantity	Key	Map No./Flight No.	Map Name/Photo Nos.	Unit Price	Amount

For orders delivered in B.C. add sales tax _____

Add Roll Fee if maps desired rolled _____

total remittance enclosed _____

Address orders to:
MAPS-B.C.
Surveys and Mapping Branch,
Ministry of Environment,
Parliament Buildings,
Victoria, British Columbia
V8V 1X4

MAIL ORDERS HAVE NO RETURNABLE VALUE
Prices are subject to change without notice

Figure B.1.

Partial enlargements are possible. To obtain a partial enlargement, mark the area required on a xerox copy of the air photograph, in black, to be sent in with the order. The marked square must be parallel to the edges of the photograph.

It is also possible to get a blowup to exact scale, provided the total blowup does not exceed 4x.

Diapositives of photographs are also available. Their main use is in photogrammetric mapping but they can also be used in overhead projectors to illustrate on screens or diazo-printed to provide cheap multiple copies. For information on diapositives contact the Map and Air Photo Sales Office in Victoria.

In cooperation with the National Air Photo Library, Ottawa, microfilm of federal air photography with the relevant air photographic indexes and catalogues for British Columbia, Yukon, and Northwest Territories is available for viewing at the provincial Air Photo Library, 533 Superior Street, Victoria. These indexes are retained on 1:500 000 map scale. Air photographs shown on them can be ordered from Ottawa by writing to:

National Air Photo Library,
Department of Energy, Mines and Resources,
615 Booth Street,
Ottawa, Ontario
K1A 0E9
Telephone: (613) 998–9900 (Telex 053–4328)

APPENDIX C

ANNOTATED SPECIES LIST

APPENDIX C

ANNOTATED SPECIES LIST

CANADA BLUEGRASS: Canada bluegrass is a native perennial capable of growing on a variety of poorly drained or infertile soils. Its dense creeping root system forms a turf which resists erosion. Numerous deep fibrous roots increase its drought tolerance.

KENTUCKY BLUEGRASS: This grass is adapted to a cool humid climate and moist well-drained soils, growing best where rainfall exceeds 0.5 metre annually. It is a sod-forming perennial with a thickly branched root system and good creeping ability.

CARLTON BROMEGRASS: The 'Carlton' variety of bromegrass has been bred from northern strains and is best adapted to growth in the northern parts of the province. It is a strongly creeping perennial which spreads by underground rhizomes.

MANCHAR BROMEGRASS: This variety of bromegrass is adapted to southern regions. It is sod forming and less strongly spreading than the Carlton variety. It maintains a good balance with legumes.

BOREAL CREEPING RED FESCUE: This grass was developed in the Peace River region and is adapted to northern conditions. It excels in seeding vigour and early spring growth, spreading by underground stems and deep roots.

MEADOW FOXTAIL: This grass appears to be well adapted to northern conditions as indicated by its success in test plot experiments in the Peace River Coalfield.

CHINOOK ORCHARDGRASS: This is a perennial bunchgrass which forms large tussocks with dense, deep roots. It grows well with alfalfa, red clover, and Ladino clover but requires 50 to 60 centimetres of rainfall annually and nitrogen fertilization to maintain high production. It has early vigorous growth and early dormancy, making it very winter hardy.

RED TOP: This shallow-rooted perennial is turf forming, spreading by short creeping rootstocks. It is adapted for wet, acid soils and has some drought tolerance once established.

PERENNIAL RYEGRASS: This is a shallow-rooted bunchgrass. It is winter hardy and has been used successfully for erosion control.

CLIMAX TIMOTHY: Timothy is a bunchgrass with fibrous roots extending to a depth of more than 1 metre. It is adapted to many conditions and grows well in all parts of the country. It has extensive above-ground growth and should be used with discretion in areas of high fire hazard.

CRESTED WHEATGRASS: This is a bunchgrass which is very drought resistant due to rapid early growth and a dense root system extending to a depth of 2 metres. It grows well on all soils. Limited top growth reduces fire hazard.

INTERMEDIATE WHEATGRASS: Intermediate wheatgrass has a deep root system as well as an extensive soo-forming system of creeping rootstocks. It has been used successfully for erosion control but its abundant top growth may increase fire hazard.

ALFALFA: Various varieties of alfalfa have been used widely for reclamation in southern parts of the province. It has some cold tolerance but is one of the crops least tolerant to low pH.

ALSIKE CLOVER: This clover is adapted to cool climates and wet soils. It does well on soils too acid or alkaline for other legumes.

WHITE CLOVER: White clover is adapted to cool, moist areas with high humidity. It is adversely affected by high temperatures with very low or high rainfall.

CICER MILKVETCH: Cicer milkvetch adapts to a wide range of soil textures but has low seeding vigour, and slow emergence making it slow to establish. It must be treated with an Astragalus bacterial innoculant before seeding.

SAINFOIN: Sainfoin has a deep-branched taproot and is adapted to dry conditions. It is not as winter hardy as many varieties of alfalfa.

APPENDIX D

RECOMMENDED RECLAMATION TREATMENTS

APPENDIX D
RECOMMENDED RECLAMATION TREATMENTS

COASTAL REGION

BIOGEO-CLIMATIC ZONE	DESCRIPTION	ELEVATION	RECLAMATION TREATMENTS SEEDING Mixture	SEEDING Rate kg/ha	SEEDING Timing	FERTILIZER Type	FERTILIZER Rate kg/ha
Coastal Douglas Fir	– includes the east coast of Vancouver Island, south of Kelsey Bay, the Sunshine Coast, and the Fraser Valley – annual precipitation high, 66-152 cm (26-60") – summers dry, winters mild – characterized by the following trees: Douglas fir, grand fir, western red cedar, arbutus, Garry oak (dry areas), lodgepole pine, Sitka spruce, bitter cherry, Vine maple, Bigleaf maple, and red alder	Southeastern Vancouver Island 0-450 m (0-1500') South Coast of Mainland 0-150 m (0-500')	I	30	avoid July and August seeding	13-16-10 (19-19-19)	300 (200)
Coastal Western Hemlock and Coastal Cedar Hemlock	– includes most of Vancouver Island and the Queen Charlotte Islands (excluding mountain tops), and the river valleys of the Pacific Coast – annual precipitation very high, 112-665 cm (44-262"); mild winters and summers – characterized by the following trees: Douglas fir, western red cedar, western hemlock, Sitka spruce, western white pine, grand fir (in dry areas), Pacific silver fir (wet areas)	South—windward side 0-900 m (0-3000') South—leeward side 450-1050 m (1500-3500') North 0-300 m (0-1000')	I	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Mountain Hemlock	– includes areas of high elevation on Pacific West Coast, Vancouver Island, and the Queen Charlotte Islands – annual precipitation high, 178-432 cm (70-170"); heavy snow cover over unfrozen ground; winters not severe – characterized by the following trees: mountain hemlock, Pacific silver fir, yellow cedar, western hemlock, western red cedar	South—windward side 900-1500 m (3000-5000') South—leeward side 1100-1800 m (3600-6000') North—300-900 m (1000-3000')	I or III	60	no restrictions	13-16-10 (19-19-19)	300 (200)
Alpine	– includes areas of high elevation, with heavy snow cover and long snow duration – low stunted growth of alpine fir, whitebark pine, mountain hemlock	windward side above 1500 m (5000') leeward side above 1800 m (6000')	VII	60	seed in early spring or late fall only	13-16-10 (19-19-19)	500 (400)

APPENDIX D *(CONTINUED)*

RECOMMENDED RECLAMATION TREATMENTS *(CONTINUED)*

SOUTHERN INTERIOR REGION

BIOGEO–CLIMATIC ZONE	DESCRIPTION	ELEVATION	RECLAMATION TREATMENTS				
			SEEDING			FERTILIZER	
			Mix-ture	Rate *kg/ha*	Timing	Type	Rate *kg/ha*
Ponderosa Pine Bunchgrass	– includes the dry river valleys of the Fraser, Thompson, Nicola, Similkameen, and Okanagan – very low precipitation, 19-36 cm (7.4-14") – characterized by the following vegetation: ponderosa pine, bitter brush, sagebrush, and bunchgrass	270-750 m (900-2500')	III	30	no restrictions early spring preferred	13-16-10 (19-19-19)	300 (200)
Interior Douglas Fir	– includes the majority of the dry Southern Interior below 1350 m (4500') – precipitation low 36-56 cm (14-22"), hot summers and cool winters – characterized by the following trees: Douglas fir, ponderosa pine, western white pine, white spruce, western red cedar, lodgepole pine, larch, aspen, black cottonwood, common paper birch, and Rocky Mountain maple	300-1350 m (1000-4500')	IV or V	30	early spring or late fall preferred	13-16-10 (19-19-19)	300 (200)
Interior Western Hemlock	– includes Interior valleys 360-1260 m (1200-4200'), east of the Selkirk Mountains – precipitation high, 56-170 cm (22-67"), warm summers and cool winters – characterized by the following trees: western hemlock, Douglas fir, white pine, lodgepole pine, western red cedar, Engelmann spruce, white spruce, alpine fir, grand fir, black cottonwood, aspen, common paper birch, larch	360-1260 m (1200-4200')	I	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Engelmann Spruce Subalpine Fir	– includes most areas greater than 1260 m (4200') in eastern British Columbia, south of Prince George – subalpine with moderate snow cover and severe winters; precipitation high, 41-183 cm (16-72") – characterized by the following trees: Engelmann spruce, alpine fir, lodgepole pine, white bark pine, alpine larch, limber pine, Douglas fir, western white pine	1260-2250 m (4200-7500')	VI	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Alpine	– includes areas in southeastern British Columbia at high elevations – low stunted trees: Engelmann spruce, alpine fir, white bark pine, alpine larch, alpine meadows and tundra	greater than 2250 m (7500')	VII	30	seed in early spring or late fall only	13-16-10 (19-19-19)	500 (400)

APPENDIX D *(CONTINUED)*

RECOMMENDED RECLAMATION TREATMENTS *(CONTINUED)*

CENTRAL AND NORTHERN INTERIOR REGION

BIOGEO–CLIMATIC ZONE	DESCRIPTION	ELEVATION	RECLAMATION TREATMENTS SEEDING Mix-ture	SEEDING Rate *kg/ha*	SEEDING Timing	FERTILIZER Type	FERTILIZER Rate *kg/ha*
Subboreal Spruce	– includes most of the central interior with elevation 330-840 m (1100-2800′) north of Williams Lake and south of Germansen Landing – Heavy snow cover; severe winters; precipitation moderate, 40-64 cm (16-25″) – Characterized by the following trees: lodgepole pine, white spruce, alpine fir, black spruce, aspen, black cottonwood, common paper birch	Central 330-840 m (1100-2800′)	V	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Engelmann Spruce Subalpine Fir	– includes areas of the central interior above 1050 m (3500′) – subalpine with moderate snow cover and severe winters; precipitation high, 41-103 cm – characterized by the following trees: Engelmann spruce, alpine fir, lodgepole pine, white spruce, white bark pine	Central and Northeast 1050-1650 m (3500-5500′) Northwest 900-1500 m (3000-5000′)	VI	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Boreal White and Black Spruce	– includes all areas below 840 m (2800′) in the northern interior – moderate or light snow cover over deeply frozen ground; winters severe; moderate precipitation, 30-58 cm (12-23″) – characterized by the following trees: white spruce, black spruce, tamarack, alpine fir, aspen, thin-leaved mountain alder, common paper birch, black cottonwood	Northeast and Northwest 163-840 m (550-2800′)	VI	30	no restrictions	13-16-10 (19-19-19)	300 (200)
Spruce Willow Birch Alpine	– includes all high elevation areas in the northern interior – moderate snow cover – characterized by stunted tree growth of alpine fir and scrub glandular birch; alpine tundra occurs at high elevations	Northeast greater than 1650 m (5500′) Northwest greater than 900 m (3000′)	VII	60	seed in early spring or late fall	13-16-10 (19-19-19)	500 (400)

APPENDIX E

SUGGESTED SEED MIXTURES
FOR USE
ON AREAS DISTURBED BY EXPLORATION ACTIVITIES
IN BRITISH COLUMBIA

APPENDIX E

SUGGESTED SEED MIXTURES FOR USE ON AREAS DISTURBED BY EXPLORATION ACTIVITIES IN BRITISH COLUMBIA

MIXTURE NO.	BIOGEOCLIMATIC ZONE	SPECIES	PERCENTAGE BY WEIGHT
I.	Coastal Douglas Fir	Timothy	10
	Coastal Western Hemlock	Perennial Rye	20
	Interior Western Hemlock	Orchard Grass	15
	Coastal Cedars, Hemlock	Creeping Red Fescue	20
		Canada Bluegrass	5
		White Dutch Clover	30
II.	Mountain Hemlock	Orchard Grass	40
		Creeping Red Fescue	40
		Perennial Rye	10
		White Dutch Clover	10
III.	Ponderosa Pine Bunchgrass	Crested Wheatgrass	70
		Alfalfa	30
IV.	Interior Douglas Fir (dry)	Streambank Wheatgrass	30
		Crested Wheatgrass	40
		Alfalfa	15
		Sainfoin	15
V.	Interior Douglas Fir (wet)	Creeping Red Fescue	30
	Sub-boreal Spruce	Timothy	20
		Orchard Grass	20
		Alsike Clover	30
VI.	Engelmann Spruce, Subalpine Fir	Creeping Red Fescue	40
	Boreal White and Black Spruce	Timothy	40
		Alsike Clover (Red Top)	20
VII.	Alpine Tundra	Meadow Foxtail	10
	Spruce, Willow, Birch	Creeping Red Fescue	40
		Timothy	25
		Tracenta Bentgrass	10
		Alsike Clover	15

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